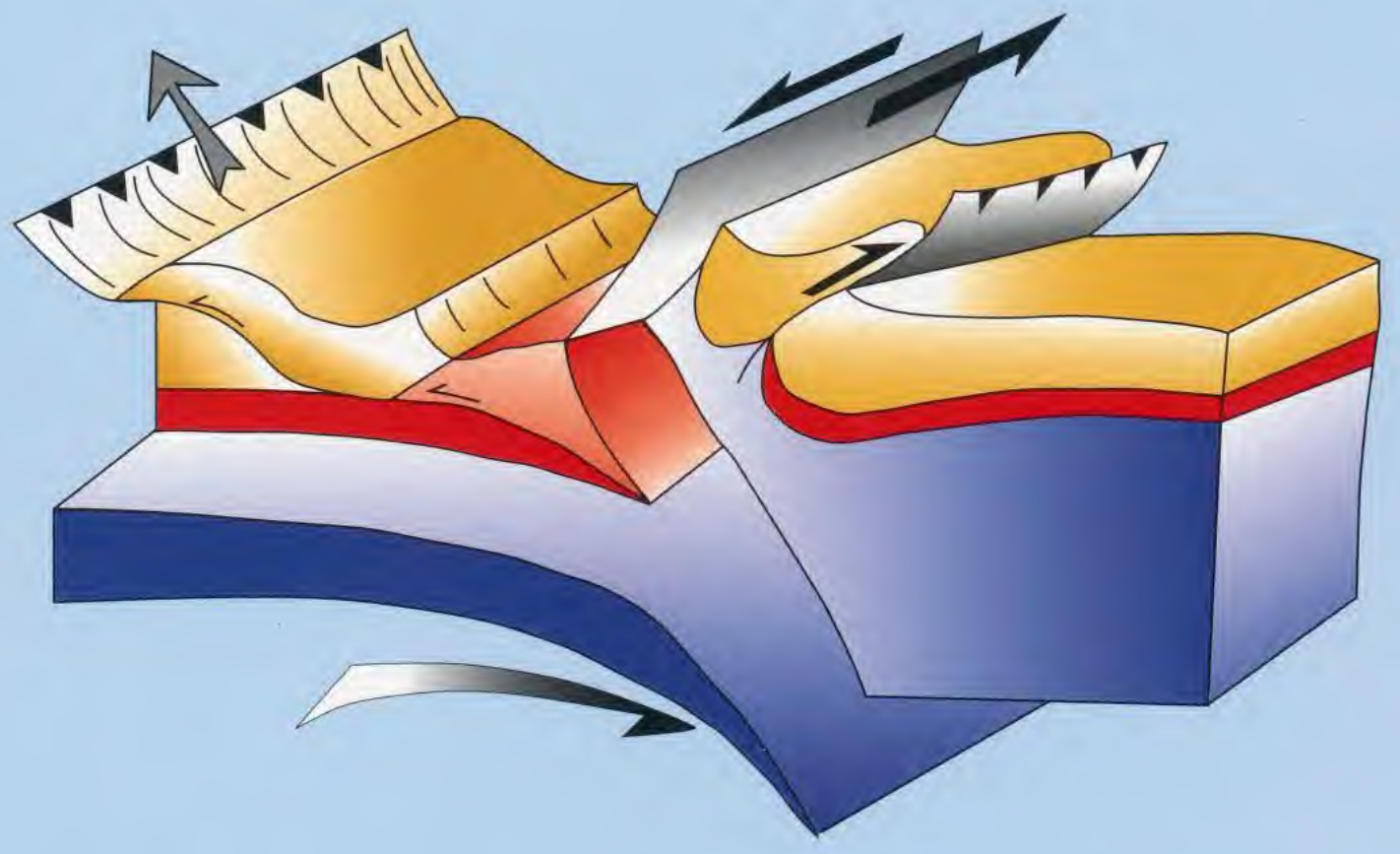
P2 260 C1 = 30 Cartes.
esplanie
Prêt = magasin.

Peri-Tethys Memoir 2

Structure and Prospects of Alpine Basins and Forelands

Edited by
Peter A. ZIEGLER
& Frank HORVÀTH



ATLAS

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1996

Source : MNHN, Paris

PLATE I

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

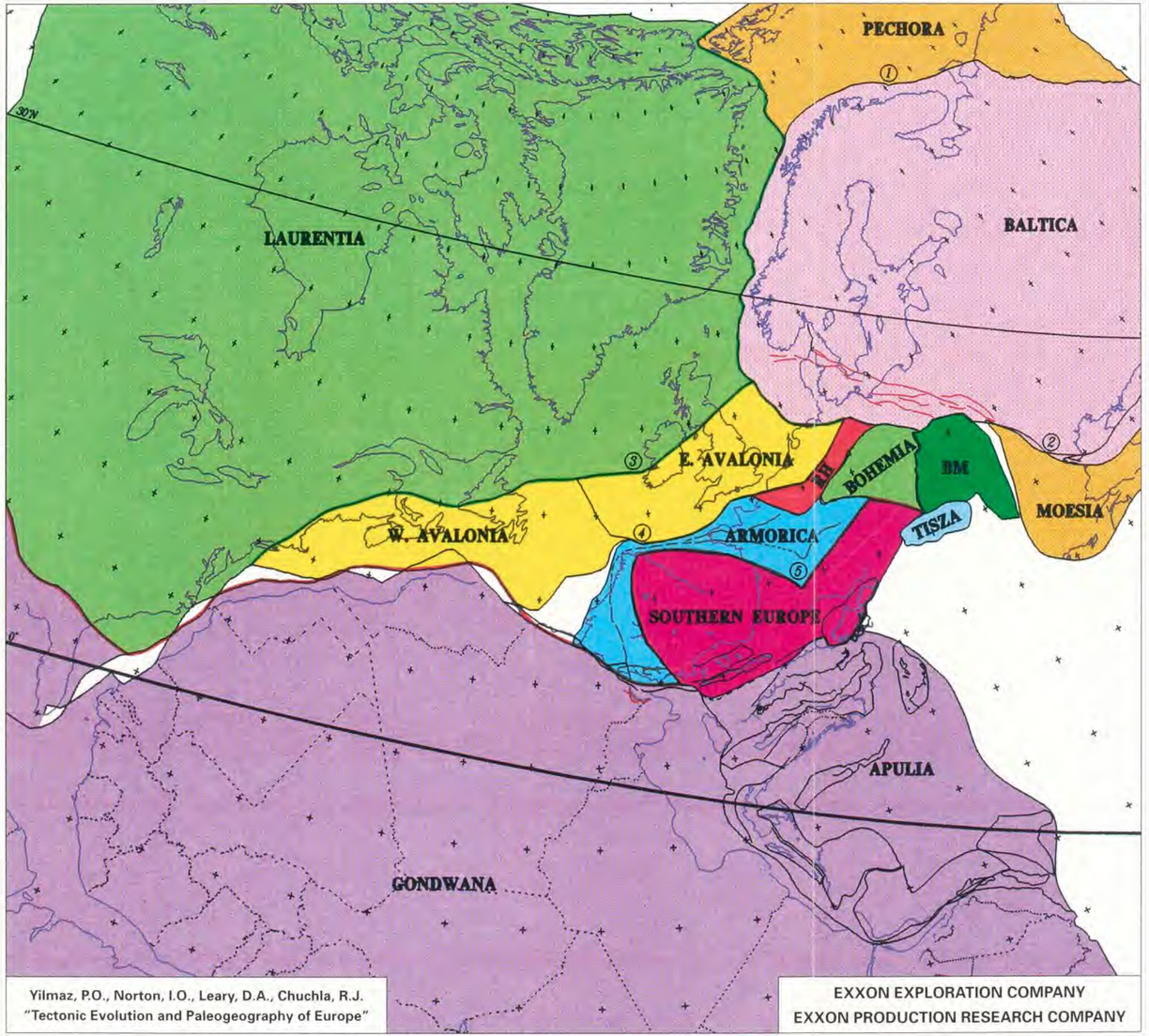
PALEOZOIC CRUSTAL BLOCKS ON PERMIAN BASE MAP

LEGEND

- Fault
- Thrust Fault
- Block Outline
- Coastline
- Political Boundaries
- Caledonian Suture (Silurian-Middle Devonian)
- Hercynian Suture (Carboniferous)

0 250 500
Kilometers
1:30,000,000

SYMBOLS:
BM = Brno-Malopolska
RH = Rheno-Hercynian Basin



FOOTNOTES:
1. Fenno-Scandian Orogeny - Late Cambrian
2. Sandomirian Orogeny - Late Cambrian
3. Caledonian Orogeny - Middle Late Silurian
4. Late Silurian - Early Devonian Collision (Avalonia vs. Armorica)
5. Hercynian Orogeny - Middle Carboniferous

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Yilmaz, P.O., Norton, I.O., Leary, D.A., Chuchla, R.J.
"Tectonic Evolution and Paleogeography of Europe"

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY

Source : MNHN, Paris

PLATE II

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

MID-CARBONIFEROUS
NAMURIAN (322 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

AM = Armorican Massif
AVC = Arverno-Vosgian Cordillera
BM = Bohemian Massif
CA = Carnic Alps
C-S = Corsica-Sardinia
D = Dobrudgea
LC = Ligerian Cordillera
RM = Rhodope Massif
SAX = Saxothuringian Basin
SIL = Upper Silesian Basin
SH = Sudetic High
SX = Saxothuringian Massif
WH = Welsh High

OVERVIEW:

- Collision of Armorican and South European blocks resulted in the Hercynian Orogeny.
- Extensive deformation is seen across Northern Europe at this time with large dextral shear along the collision zone. Syn-tectonic granites and continental clastics occur along the deformation front.
- Flysch was deposited in the Cantabrian and Rhenish basins.

FOOTNOTES:

1. Marine connection existed through Tethys.
2. Deep marine Culm facies were deposited in the Rhenish basin.
3. The Apulian block was characterized by neritic sedimentation.

YILMAZ, P. O., NORTON, I. O., LEARY, D. & CHUCHLA, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, 170: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

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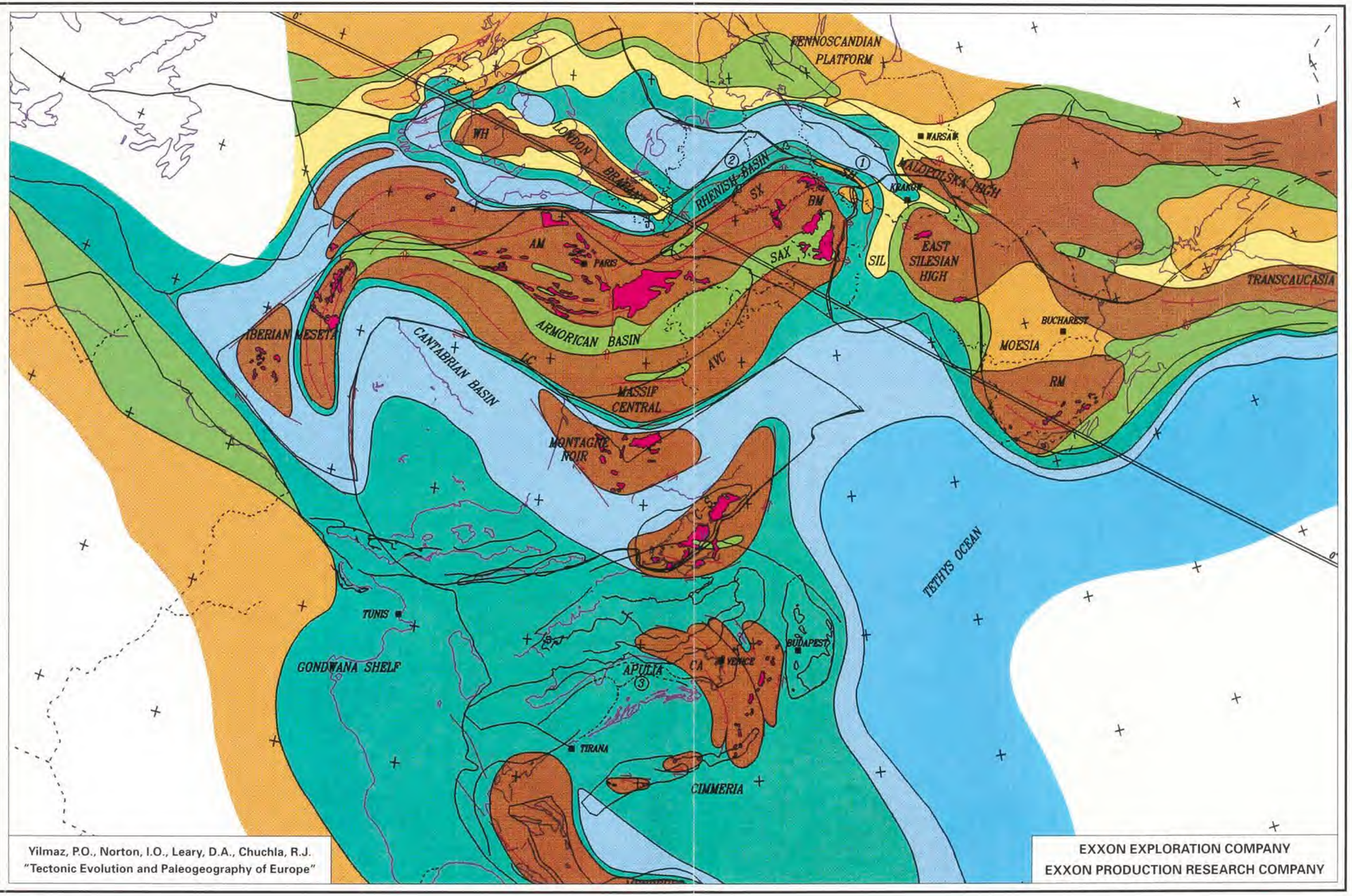

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"Tectonic Evolution and Paleogeography of Europe"

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EXXON PRODUCTION RESEARCH COMPANY

Source : MNHN, Paris

PLATE III

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

UPPER CARBONIFEROUS
WESTPHALIAN A/B (306 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

AM = Armorican Massif
AVC = Arverno-Vosgian Cordillera
BM = Bohemian Massif
CA = Carnic Alps
C-S = Corsica-Sardinia
D = Dobrudgea
PT = Polish Trough
RM = Rhodope Massif
SAX = Saxothuringian Zone
SB = Saar Basin
SIL = Upper Silesian Basin
WH = Welsh High

OVERVIEW:

- The Variscan phase of Hercynian deformation consisted of faulting, folding, emplacement of post-tectonic granitic intrusives, and thick continental sedimentation in the developing foredeep.
- Flysch was deposited in the Cantabrian basin and Carnic Alps.

FOOTNOTES:

1. Thick coal measures were deposited in the foreland basin.
2. Marine connection was cut off as the foredeep filled in Northern Europe.
3. The upper Silesian basin records the northeastward migration of the Hercynian deformation front. This basin was initially part of the Hercynian foredeep but was stranded as an intermontane basin as the deformation front swept to the northeast.
4. Apulian shelf sedimentation was locally disrupted by Variscan tectonism.

YILMAZ, P. O., NORTON, I. O., LEARY, D. & CHUCHLA, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, 170: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

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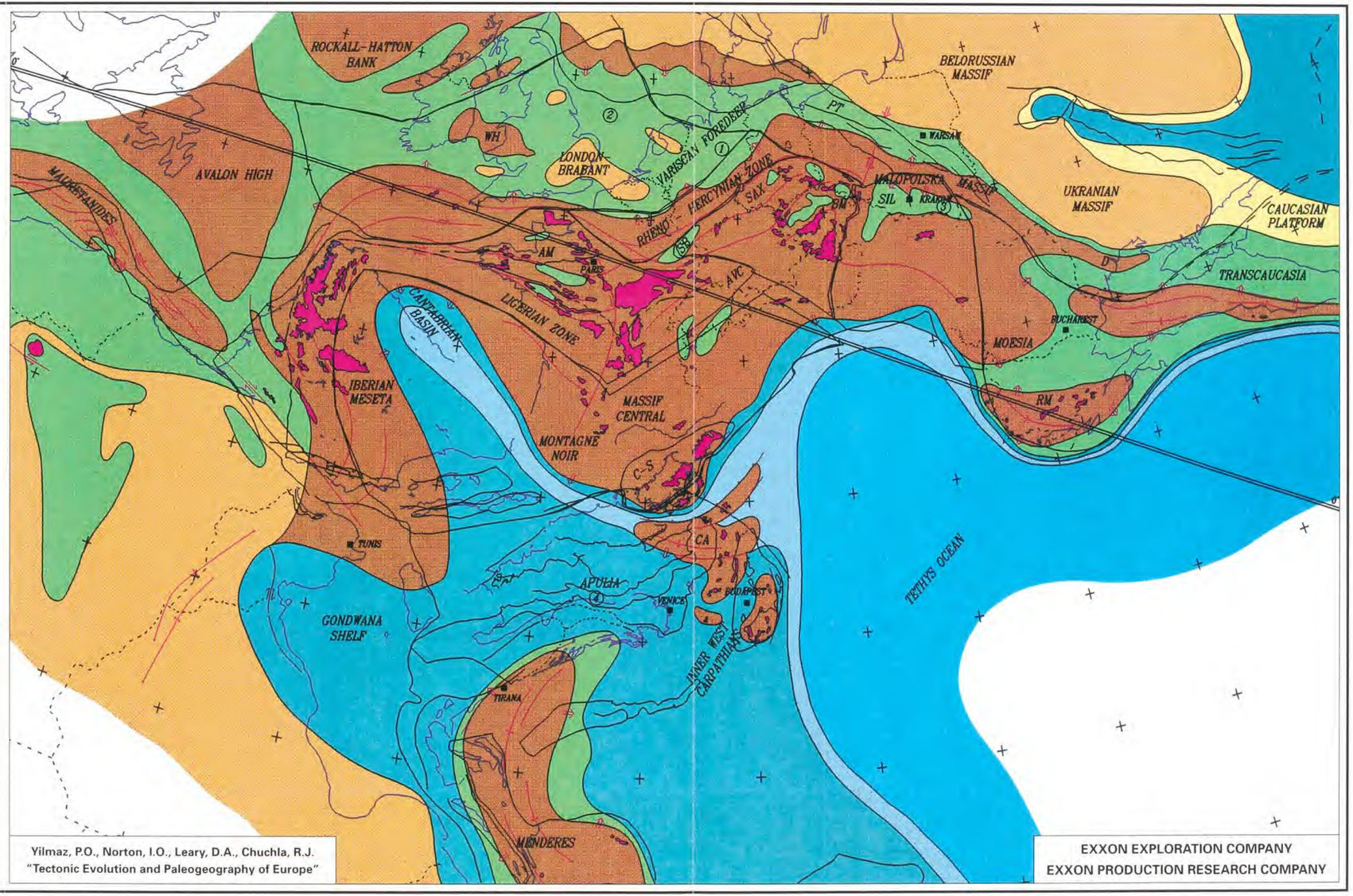

Yilmaz, P.O., Norton, I.O., Leary, D.A., Chuchla, R.J.
"Tectonic Evolution and Paleogeography of Europe"

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY

Source : MNHN, Paris

PLATE IV

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

LOWER PERMIAN
ROTLIEGENDES (254 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

C-S = Corsica-Sardinia
D = Dobrudgea
NSH = Mid-North Sea High
PT = Polish Trough
RM = Rhodope Massif
WAT = Western Approaches Basin
WH = Welsh High

OVERVIEW:

- Post-Hercynian orogenic collapse resulted in rifting and volcanism, and localized subsidence and sedimentation.
- Autunian volcanism in Germany and Poland was followed by lacustrine deposition in intermontane grabens.

FOOTNOTES:

1. Deposition was mostly non-marine with intermittent marine influence. Rotliegendes clastic reservoir facies were deposited.
2. Sedimentation was accommodated partially by thermal subsidence but mostly by space provided by the relict Variscan foredeep.
3. Possible dextral shear between Gondwana and Fennosarmatia created intracontinental transform systems resulting in local transtension and formation of pull-apart basins. Faults have relatively small displacement and grabens are filled with continental clastics.
4. Deposition of continental evaporites characterized the southern European margin.
5. Marine shelf sedimentation occurred in the Apulian area. Rifting initiated and red beds were deposited (Verrucano facies of the Alps).

Yilmaz, P. O., Norton, I. O., Leary, D. & Chuchla, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In*: Ziegler, P. A. & Horváth, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, 170: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

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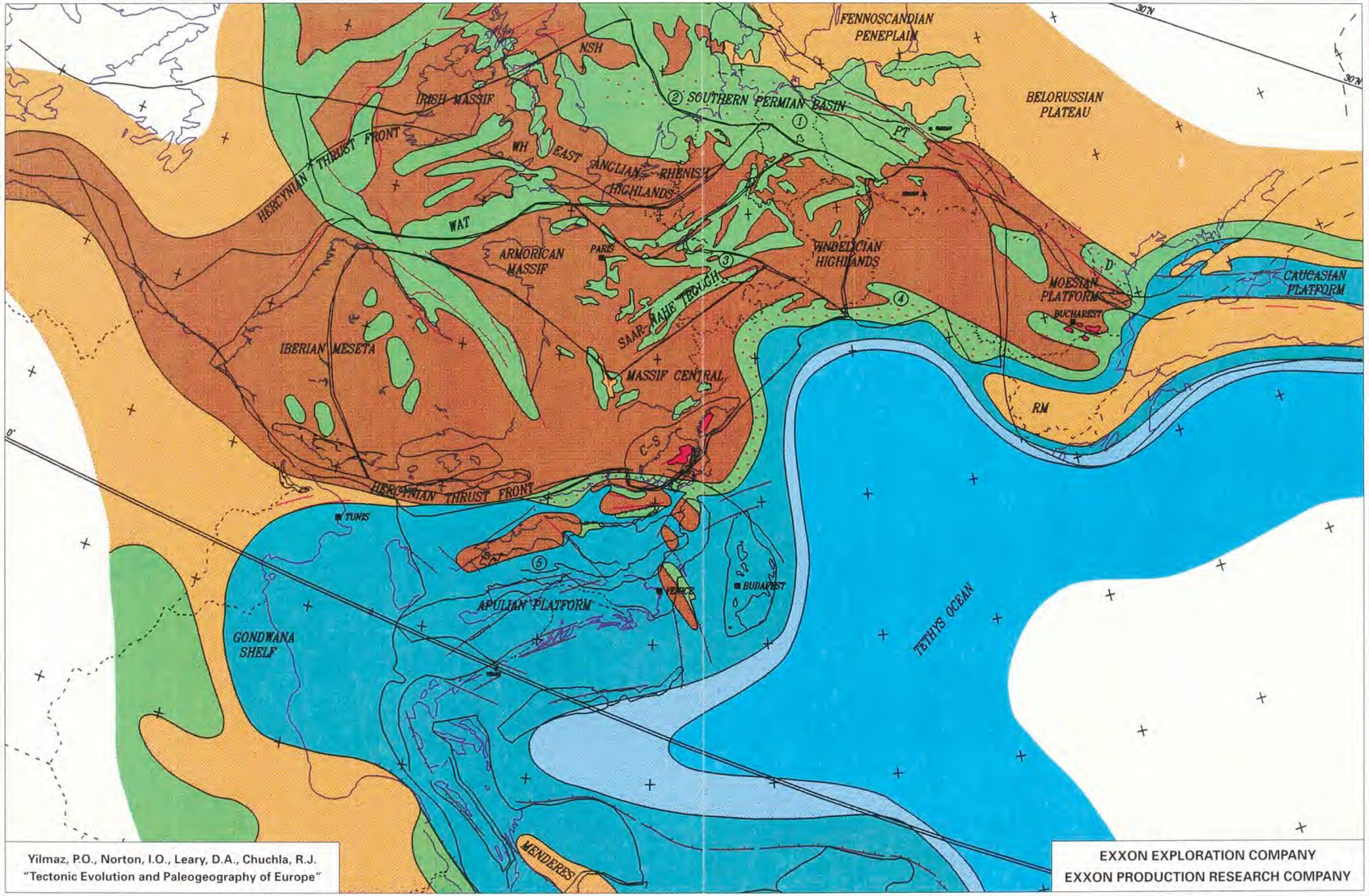

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"Tectonic Evolution and Paleogeography of Europe"

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Source : MNHN, Paris

PLATE V

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

UPPER PERMIAN
ZECHSTEIN (251 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

B-C = Budva-Cukali Basin
BM = Bohemian Massif
C-S = Corsica-Sardinia
D = Dobrudgea
EME = Eastern Mediterranean Basin
LN = Lago Negro Basin
LOM = Lombardi Basin
NSH = Mid-North Sea High
PT = Polish Trough
REN = Rhenish Massif
RM = Rhodope Massif
WAT = Western Approaches Trough
WH = Welsh High

OVERVIEW:

- Extensive faulting continued during continental clastic sedimentation. The collapse of the Hercynian orogeny setup Mesozoic rifting events in southern Europe and North Africa.

FOOTNOTES:

1. Marine connection was established with the transgression of Arctic (Boreal) seas into the area of the Southern Permian basin. This transgression is represented by the Kupferschiefer facies. In this inland Zechstein sea, eustatic cycles generated alternating carbonate and evaporite deposits.
2. Boreal Zechstein and Tethyan seas were initially connected via Dobrudgea. This connection was severed during deposition of the Main Dolomite.
3. The Apulian platform was rifted. Evaporite and continental facies were deposited.
4. Eastern Mediterranean rift propagated westward.
5. Indicates the conceptual position of Cimmerian blocks that collided with the Moesian platform during Late Triassic time.

YILMAZ, P. O., NORTON, I. O., LEARY, D. & CHUCHLA, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

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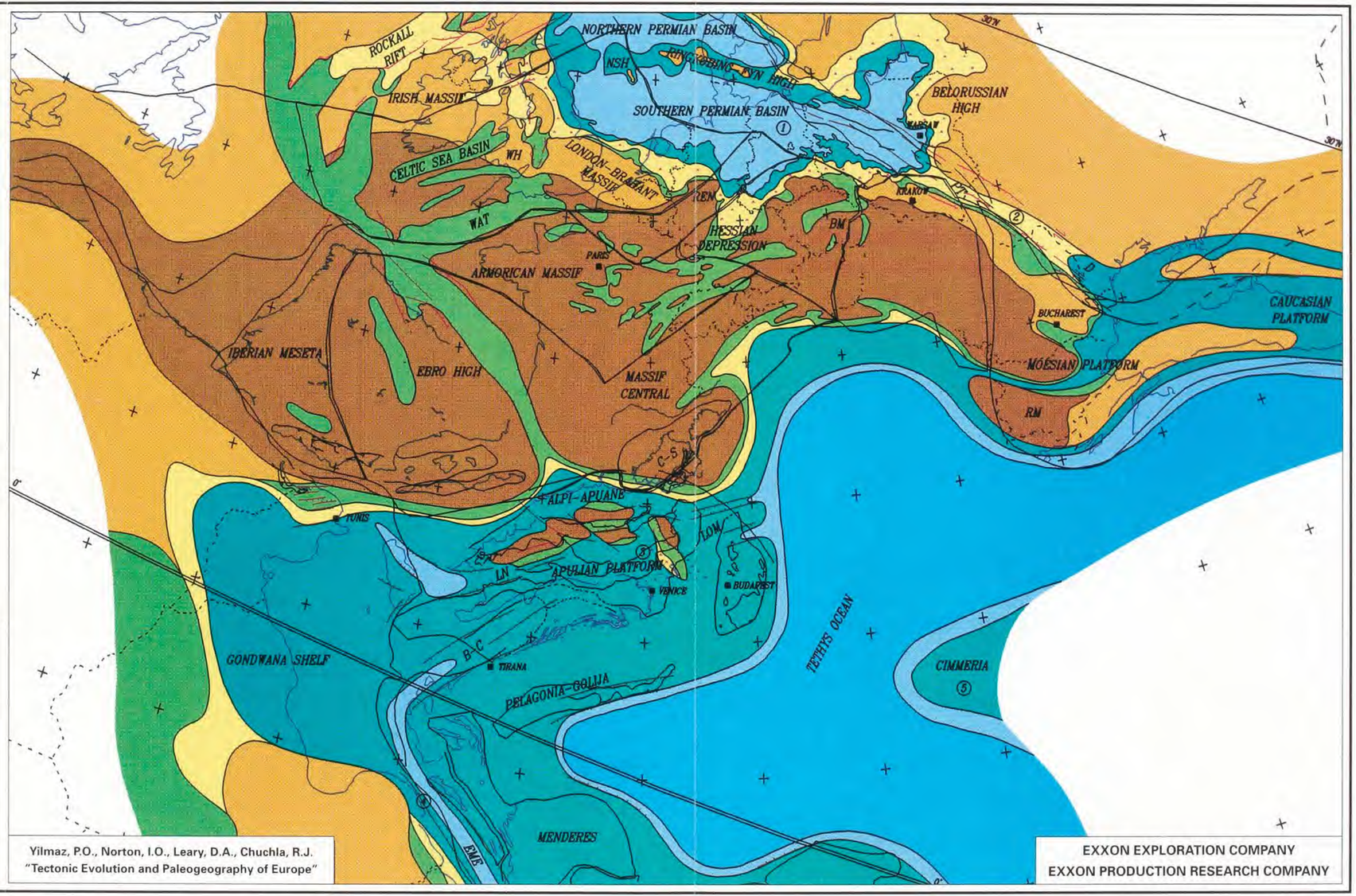


Yilmaz, P.O., Norton, I.O., Leary, D.A., Chuchla, R.J.
"Tectonic Evolution and Paleogeography of Europe"

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY

Source : MNHN, Paris

PLATE VI

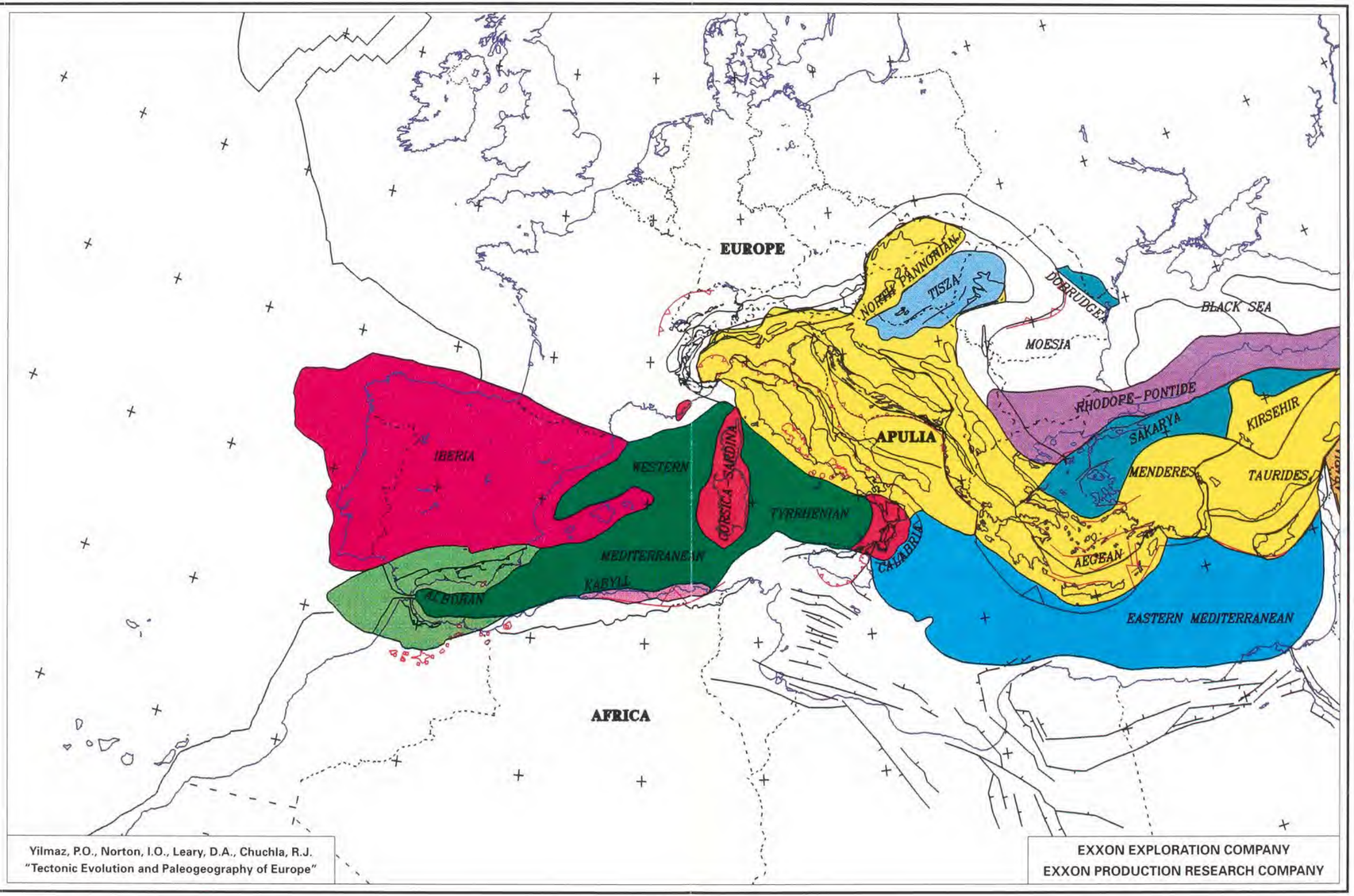
EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

MESOZOIC CRUSTAL BLOCKS ON PRESENT-DAY BASE MAP

LEGEND

- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries
- Tertiary Volcanics

0 250 500
Kilometers
1:15,000,000



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EXXON PRODUCTION RESEARCH COMPANY

Source : MNHN, Paris

PLATE VII

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

UPPER TRIASSIC
RHAETIAN (210 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

B	=	Brianconnais
B-C	=	Budva-Cukali Basin
C-A	=	Cantabrian-Aquitaine Basin
C-S	=	Corsica-Sardinia
FP	=	Friuli Platform
GIB	=	Gibraltar
J	=	Julian Platform
LOM	=	Lombardi Basin
PEL	=	Pelagonian Massif
PH	=	Pyrenean High
PIN	=	Pindos Zone
RM	=	Rhodope Massif
S-I	=	Strepenossa-Imerese Basin
VH	=	Vindelician High
WH	=	Welsh High

YILMAZ, P. O., NORTON, I. O., LEARY, D. & CHUCHLA, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, 170: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

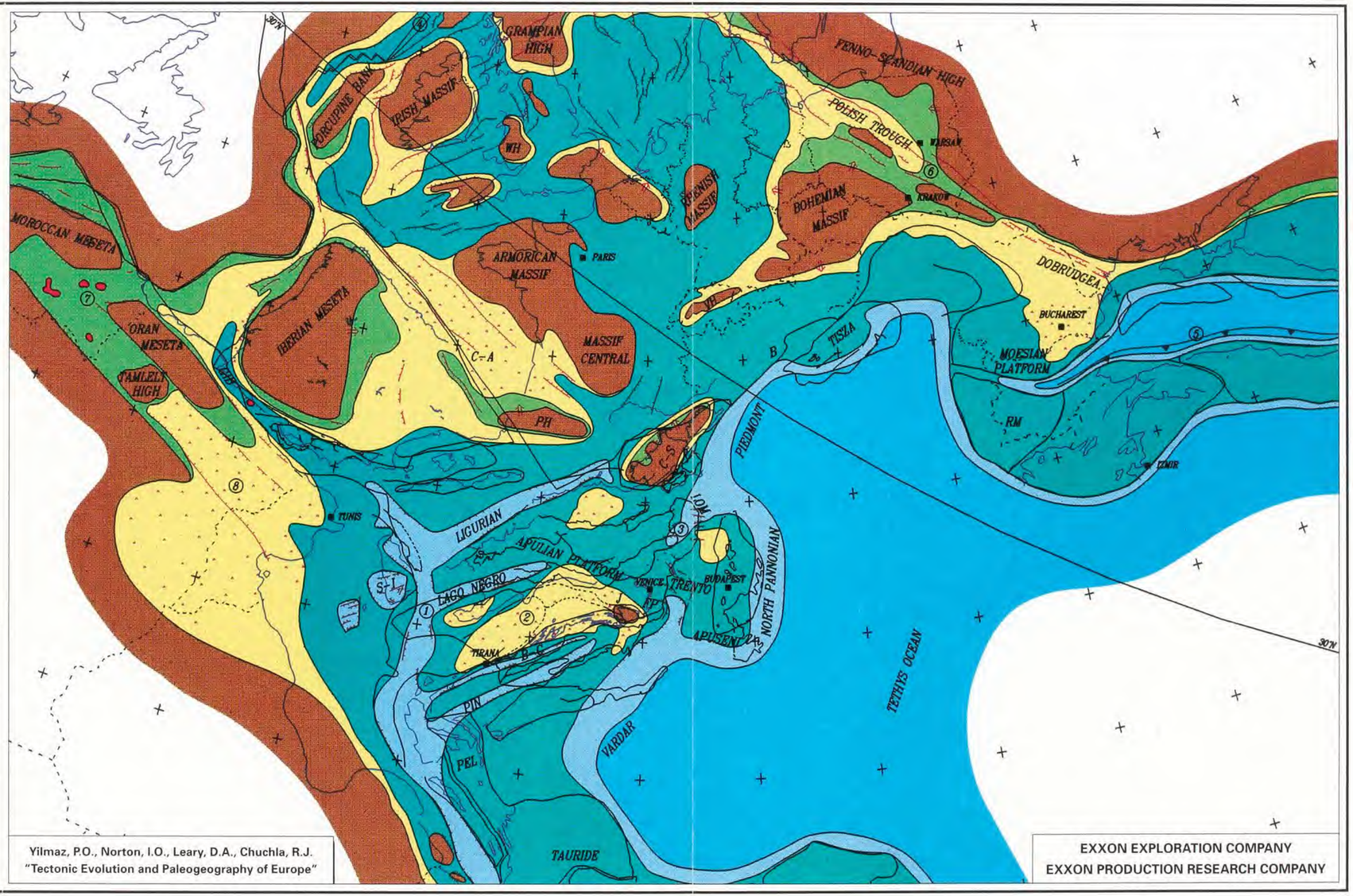
OVERVIEW:

- Triassic was characterized by regional extension with a system of multidirectional grabens superimposed on and partially controlled by Hercynian structural trends.

FOOTNOTES:

1. Tethyan oceanic rifting propagated westward. Rifting manifested itself in extensive fault-bounded troughs filled with Verrucano conglomerate facies. Alternating platform/basin paleogeography characterized the Apulian block.
2. The Burano Formation was deposited in shallow water evaporitic basins.
3. Deep water clastics (Riva di Solto Fm.) were deposited in half-grabens in the Po basin. Kossen marl deposition was dominant on the shallow North Pannonian platform.
4. Norwegian-Greenland rift propagated south.
5. During the Late Triassic, long-standing south-facing subduction of Paleo-Tethys ocean ended with the collision of Cimmerian blocks with Europe.
6. Cimmerian deformation of Late Triassic-Early Jurassic manifested in the Polish Trough as local angular unconformities.
7. Continental clastic deposition and alkaline (rift) volcanism occurred in Morocco.
8. Widespread coastal plain, inner shelf sabkha facies and clastic deposition dominated North Africa.

BIBL. DU MUSEUM PARIS



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"Tectonic Evolution and Paleogeography of Europe"

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY

Source : MNHN, Paris

PLATE VIII

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

LOWER JURASSIC
TOARCIAN (179 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

B	=	Brianconnais
B-C	=	Budva-Cukali Basin
BEL	=	Belluno Platform
C	=	Crimea
CM	=	Cornubian Massif
C-S	=	Corsica-Sardinia
D	=	Dobrudgea
FP	=	Friuli Platform
L-C	=	Lisbon-Cavalla Basins
LOM	=	Lombardi Basin
P	=	Provence
PH	=	Pyrenean High
PIN	=	Pindos Zone
PT	=	Polish Trough
R	=	Rharb Basin
RM	=	Rhodope Massif
SA	=	Saharan Atlas
SAP	=	South Apuseni
TP	=	Trento Platform
WH	=	Welsh High

OVERVIEW:

- Tethyan rift system remained active. Regional subsidence was associated with extension.
- Extensive marine connection was established between Arctic and Tethyan seas.

FOOTNOTES:

1. Active flysch deposition continued along the Cimmerian deformation front (Nalbantian flysch, Tauridian flysch and Akgol flysch basins). Structures indicate Early Jurassic deformation. Dogger plutons stitch the suture zone.
2. Rifting developed into crustal separation in Eastern Mediterranean (Antalya area).
3. Alternating platform/basin paleogeography continued to characterize Apulia. Significant progradation of carbonate platforms occurred.
4. Rifting of the Brianconnais and Tisza blocks opened the Valais trough.

YILMAZ, P. O., NORTON, I. O., LEARY, D. & CHUCHLA, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In*: ZIEGLER, P. A. & HORVATH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, 170: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

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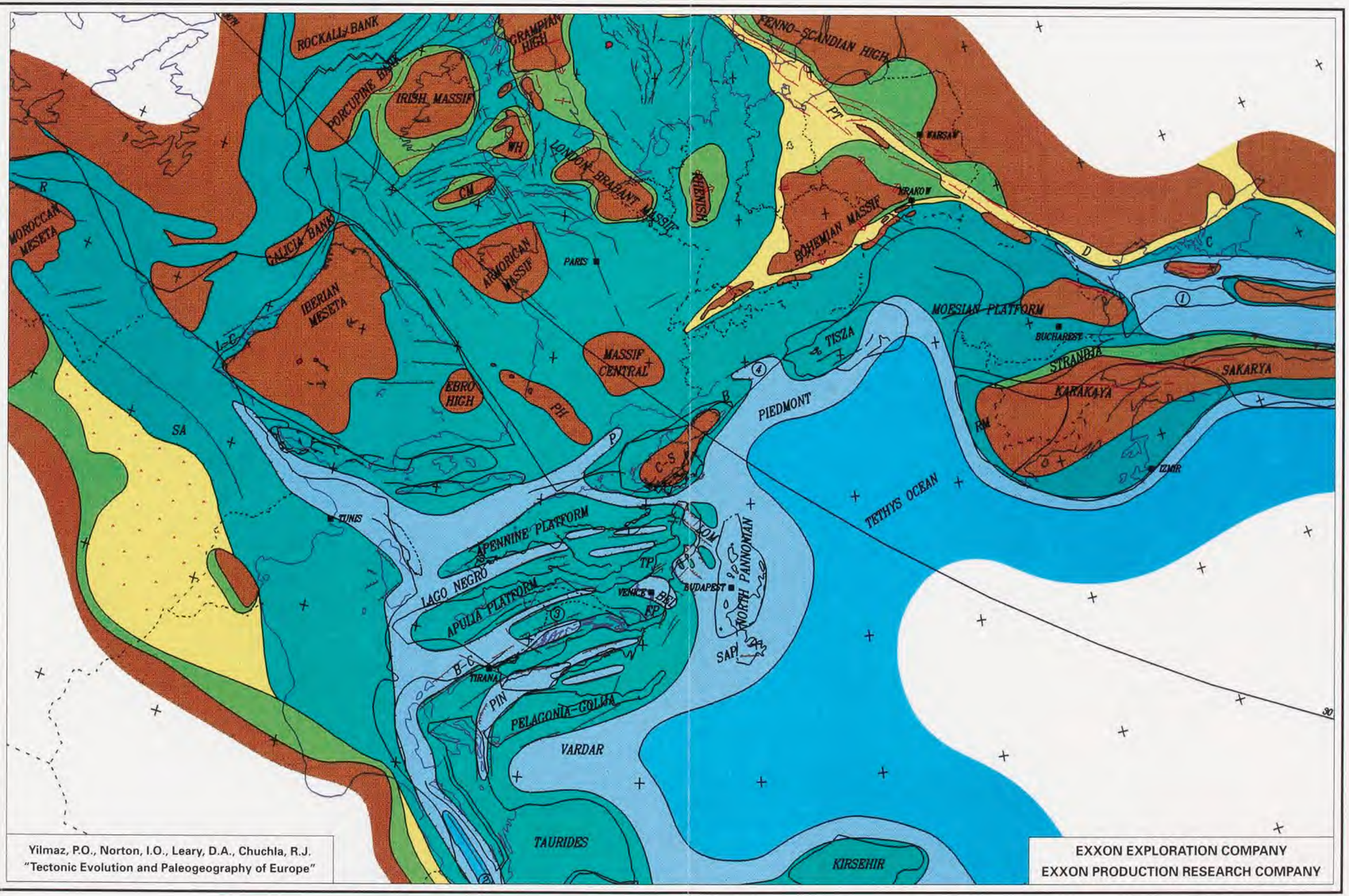


Yilmaz, P.O., Norton, I.O., Leary, D.A., Chuchla, R.J.
"Tectonic Evolution and Paleogeography of Europe"

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY

Source : MNHN, Paris

PLATE IX

EXXON EXPLORATION COMPANY
EXXON PRODUCTION RESEARCH COMPANY
EUROPEAN REGIONAL STUDY

MIDDLE JURASSIC
BATHONIAN (158.5 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

B = Brianconnais
C = Crimea
C-A = Cantabrian-Aquitaine Basin
C-S = Corsica-Sardinia
D = Dobrudgea
FP = Friuli Platform
G = Gibraltar
ME = Mecsek
MP = Moesian Platform
PH = Pyrenean High
PT = Polish Trough
SA = Saharan Atlas
SAP = South Apuseni
TP = Trento Platform
TR = Transylvanian Ophiolites
V-B = Villany-Bihor
WH = Welsh High

YILMAZ, P. O., NORTON, I. O., LEARY, D. & CHUCHLA, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

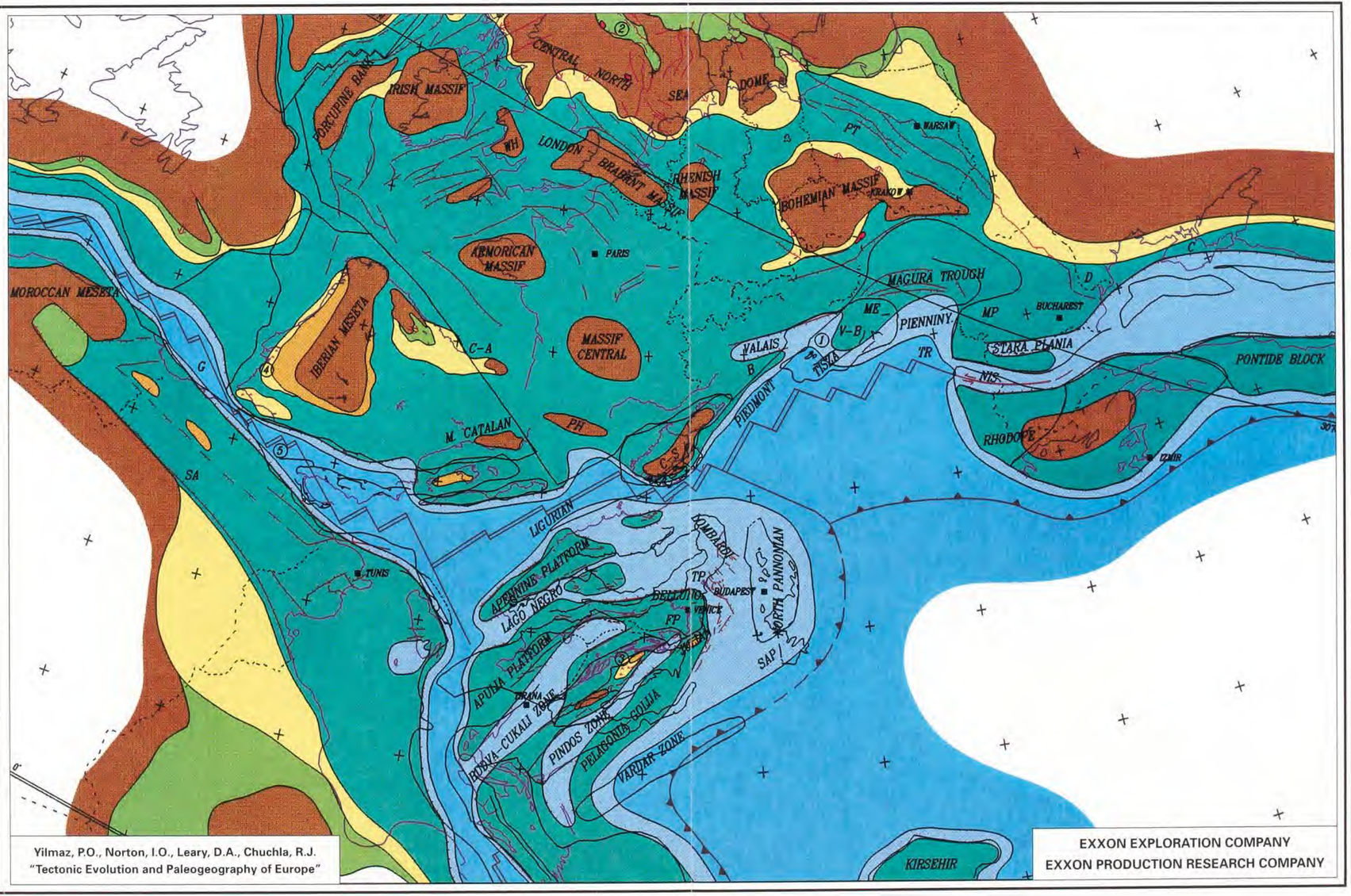
OVERVIEW:

- Earlier rifting events continue to crustal separation and the onset of sea-floor spreading.
- Plate motions between Europe and Gondwana changed as the central Atlantic started to open.
- A connection was established between the western Tethys ocean and central Atlantic.
- Apulia decoupled from Gondwana.
- Liguride, Piedmont, Transylvanian and Vardar ophiolites evidence formation of oceanic crust along the Tethyan spreading center.

FOOTNOTES:

1. The Valais trough fully opened as the Brianconnais and Tisza platforms rifted further from Europe. Full decoupling of the Tisza block from Europe occurred in Tithonian time.
2. Continental clastics and alkaline magmatism characterized North Sea rifting.
3. Local evaporitic basins developed on the Dinaride platforms.
4. The Lisbon and Algarve basins were sites of evaporite deposition.
5. Spreading ridge between North Africa and Iberia is conceptual.

BIBL. DU MUSEUM PARIS



Yilmaz, P.O., Norton, I.O., Leary, D.A., Chuchla, R.J.
"Tectonic Evolution and Paleogeography of Europe"

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Source : MNHN, Paris

PLATE X

EXXON EXPLORATION COMPANY
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EUROPEAN REGIONAL STUDY

LOWER CRETACEOUS
APTIAN (112 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

A-A	=	Austro-Alpine (Upper)
B	=	Brianconnais
C	=	Crimea
C-A	=	Cantabrian-Aquitaine Basin
CM	=	Cornubian Massif
CR	=	Czorztyn Ridge
C-S	=	Corsica-Sardinia
G	=	Getic Zone
GAV	=	Gavrova Platform
H	=	Hellenides
J	=	Julian Platform
L-A	=	Latium-Abruzzi
LIG	=	Ligurian Ophiolites
M	=	Marmoras Basin
P	=	Pennide Fracture Zone
PH	=	Pyrenean High
PT	=	Polish Trough
SA	=	Saharan Atlas
SAP	=	South Apuseni
S-M	=	Serbo-Macedonian Massif

OVERVIEW:

- Major plate reorganization occurred as Africa changes course from east to north relative to Europe in response to crustal separation in the central Atlantic. North Atlantic opening initiated.
- Counterclockwise rotation of Iberia resulted in left-lateral shear along the North Pyrenean fault zone. Oceanic crust developed in Bay of Biscay.
- Rotation of Apulia caused obduction of ophiolites of Late Jurassic to Early Cretaceous age. Tithonian ophiolitic flysch was locally deposited in Greece, Yugoslavia, Italy and Switzerland.
- Carbonate platforms reached their maximum extent in Apulia.
- Deformation resulting from the collision of Apulia with Europe initiated in Late Cretaceous time. The collision front propagated to the north. Direct continent/continent collision occurred in the middle Eocene.
- Iberia rotated clockwise and collided with Europe causing Pyrenean deformation during the Eocene.

FOOTNOTES:

1. Meso-Alpine Orogeny: Tisza block collided with and attached to Apulia as thrusting, folding and flysch deposition occurred in the Apuseni mountains and Austro-Alps.
2. Apulian platform failed along inherited Mesozoic lines of weakness. An east-dipping subduction zone initiated in front of Golija and Pelagonian platforms.
3. Moesia and Rhodope collided. Deformation is manifested in the Getic zone of the Carpathians.
4. Black Sea backarc rifting initiated above the north-dipping subduction zone along the Tethyan margin.

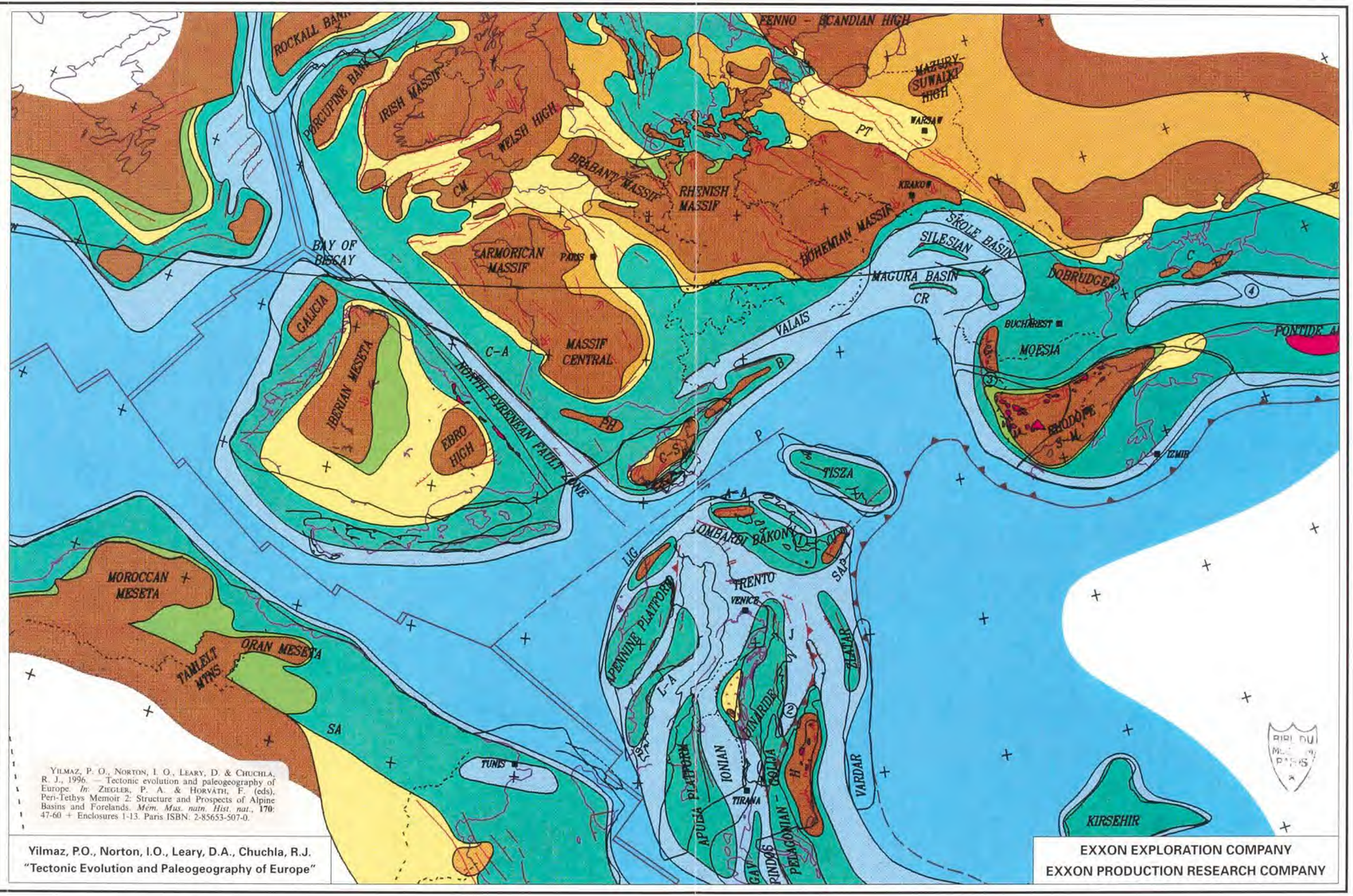

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PLATE XI

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EUROPEAN REGIONAL STUDY

LOWER OLIGOCENE
RUPELIAN (33.5 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

A	=	Albanides
AH	=	Alboran High
C-S	=	Corsica-Sardinia
H	=	Hellenides
L-A	=	Latium-Abruzzi
MB	=	Molasse Basin
MN	=	Macla Nappe
MT	=	Molisse Trough
PB	=	Podhale Basin
PKB	=	Pienniny Klippen Belt
RM	=	Rhodope Massif
SG	=	Srednogoria
TN	=	Tuscan Nappes
TP	=	Trento Platform
VT	=	Varna Trough

YILMAZ, P. O., NORTON, I. O., LEARY, D. & CHUCHLA, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, 170: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

OVERVIEW:

- Map depicts paleogeography after the Apulian-European collision event of Eo-Alpine Orogeny. Deformation continued in the Alpine and Carpathian mountain belts accompanied by molasse and flysch deposition.
- The Alps and Dinaride mountain systems were characterized by advancing subduction boundaries where overall plate convergence exceeded the rate of subduction. Diagnostic features include basement-involved thrusting, high topography, tectonic denudation via low angle normal faulting, and exposure of high-grade metamorphic rocks at the surface. Foredeeps manifest a protracted history of molasse deposition. Subsidence in the area of the foredeep resulted from the adjacent structural load. This collision boundary shuts off as continent/continent collision takes place in late Eocene time.

FOOTNOTES:

1. Compression was initiated in the Outer Carpathians and extension began in the Pannonian basin. Compression was driven by the north Pannonian and Tisza blocks which were shouldered into the Pannonian embayment by the northward advancing Apulian promontory. Volcanism around the Carpathian arc began during the late Oligocene and resulted from subduction of highly attenuated European continental crust beneath the overriding fold-thrust belt.
2. Compression was initiated within the Apennines and accompanied by flysch sedimentation.
3. Peri-Adriatic calcalkaline plutons and minor volcanic flows were emplaced between 32-30 Ma.
4. Rifting and associated volcanism began in the Rhine in the late Eocene. It propagated to the Bresse, Limagne, Rhone and Valencia troughs.
5. Incipient backarc rifting above a northwest dipping subduction zone was responsible for the initial rifting of the Corsica-Sardinia blocks from Europe.

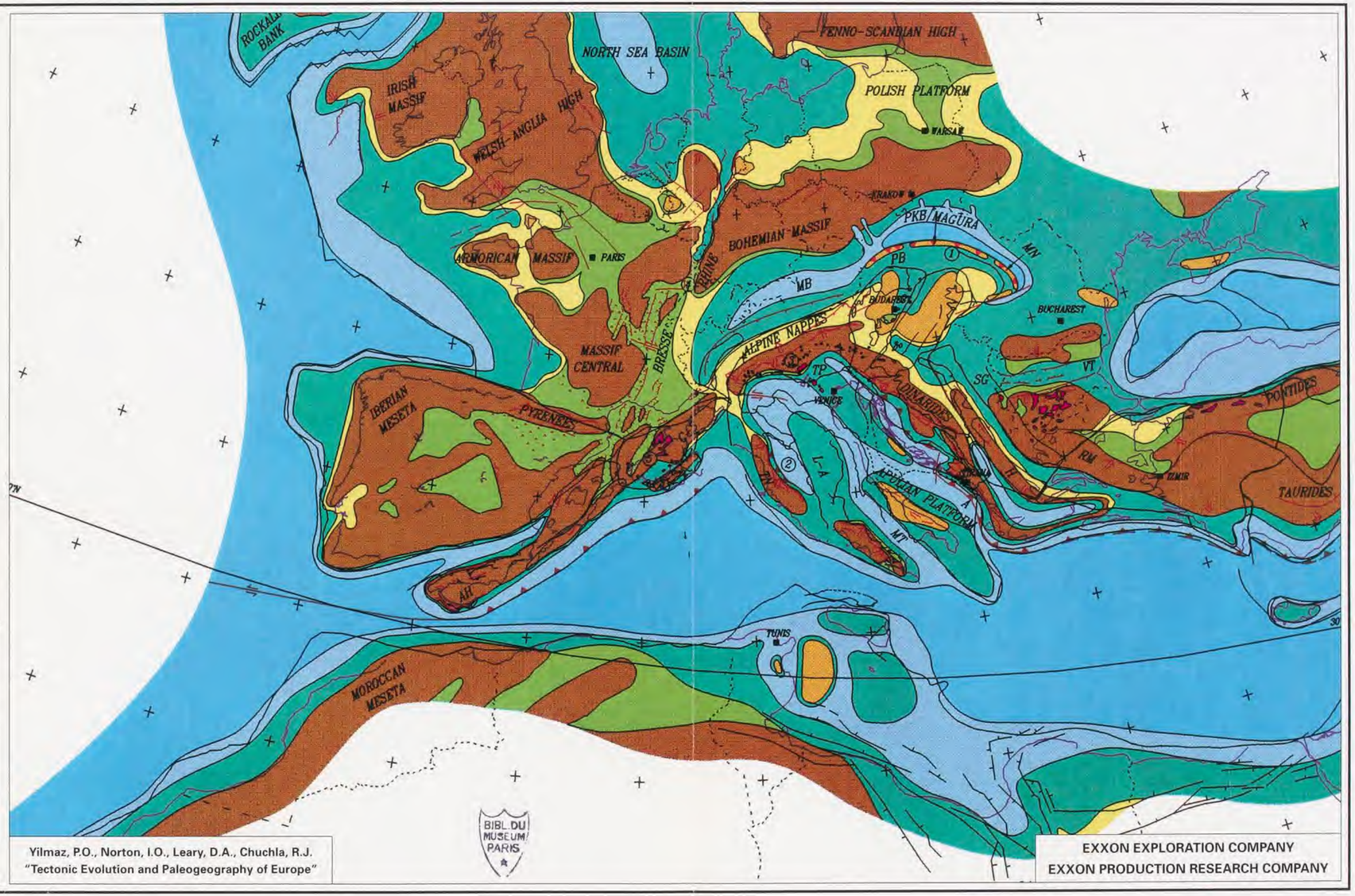

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PLATE XII

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EUROPEAN REGIONAL STUDY

MIDDLE MIOCENE
SERRAVALIAN (10.5 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

A	=	Albanides
C-S	=	Corsica-Sardinia
DI	=	Dinarides
E	=	Eger Graben
H	=	Hellenides
M	=	Menderes Massif
PKB	=	Pienniny Klippen Belt
RM	=	Rhodope Massif
U-M	=	Umbria-Marche

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OVERVIEW:

- The Alpine-Carpathian deformation front continued its northwestward and northeastward advance accompanied by extensive flysch and molasse deposition.
- The Apennine and Carpathian mountain systems were dominated by retreating subduction boundaries where overall plate convergence was less than the rate of subduction. These orogens are characterized by low average elevation, thin skinned deformation, contemporaneous backarc extension and subsidence in the area of the foredeep far in excess of that which would result from the adjacent structural load.

FOOTNOTES:

1. The Corsica-Sardinia and Kabyl blocks separated from Europe rotating counterclockwise and backarc extension progressed to the oceanic stage opening the present Western Mediterranean Sea.
2. Relict Tethyan ocean continued to be consumed along the Albanian and Hellenic boundary after subduction beneath the Dinarides terminated.
3. Back thrusting in the Southern Alps initiated subsidence in the Po foredeep.
4. Deformation terminated in a clockwise fashion around the Carpathian loop in concert with volcanic activity. By the end of Miocene time, deformation had stopped in all but the Romanian portion of the Carpathians. Significant backarc extension continued in the Pannonian basin.
5. Subduction boundary is found in the South Carpathians where the remaining consumable crust is being destroyed.
6. Alboran block escaped westwards resulting in Betic/Rif deformation.

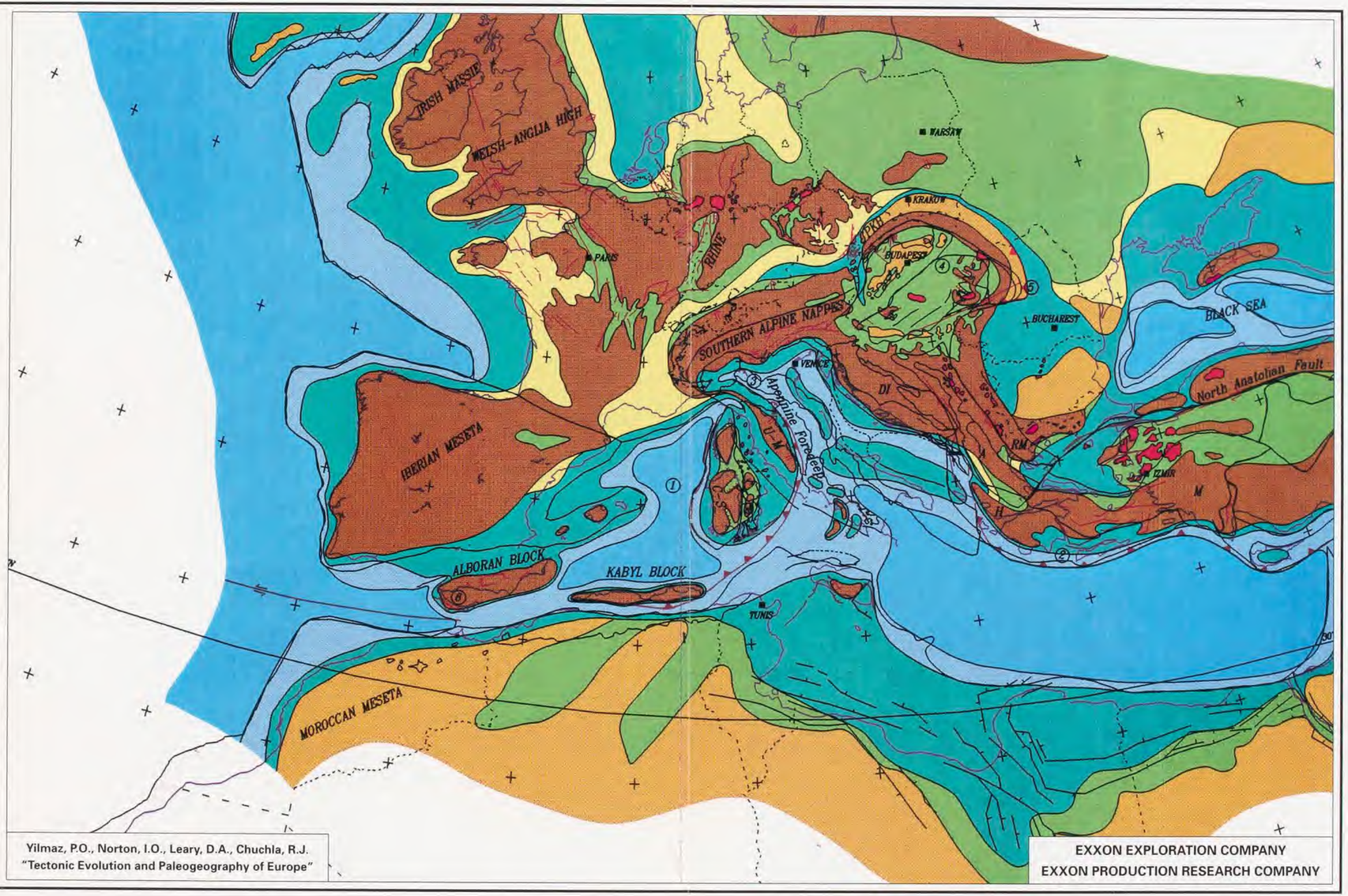

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PLATE XIII

EXXON EXPLORATION COMPANY
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EUROPEAN REGIONAL STUDY

LOWER PLIOCENE (3.8 MA) PALEOGEOGRAPHY

LEGEND

- Continental Highlands (Sediment Source)
- Continental Lowlands (Sediment Bypass)
- Continental, Fluvial, Lacustrine Deposition
- Coastal Plain, Deltaic to Inner-Shelf Deposition
- Shelf Deposition
- Basin or Slope Deposition
- Deep Ocean Deposition
- Magmatism Related to Convergence
- Magmatism Related to Extension
- Evaporites
- Spreading Center
- Active Subduction
- Transform Fault
- Thrust Fault
- Strike-Slip Fault
- Normal Fault
- Fault
- Folds
- Sediment Source
- Block Outline
- Coastline
- Political Boundaries

0 250 500
Kilometers
1:15,000,000

SYMBOLS:

AE = Aegean Sea
BA = Balaton Fault
CAL = Calabria
C-S = Corsica-Sardinia
MH = Mid-Hungarian Shear Zone
MT = Molise Trough
RM = Rhodope Massif
SCF = South Carpathian Foredeep
TS = Tyrrhenian Sea
VIE = Vienna Basin

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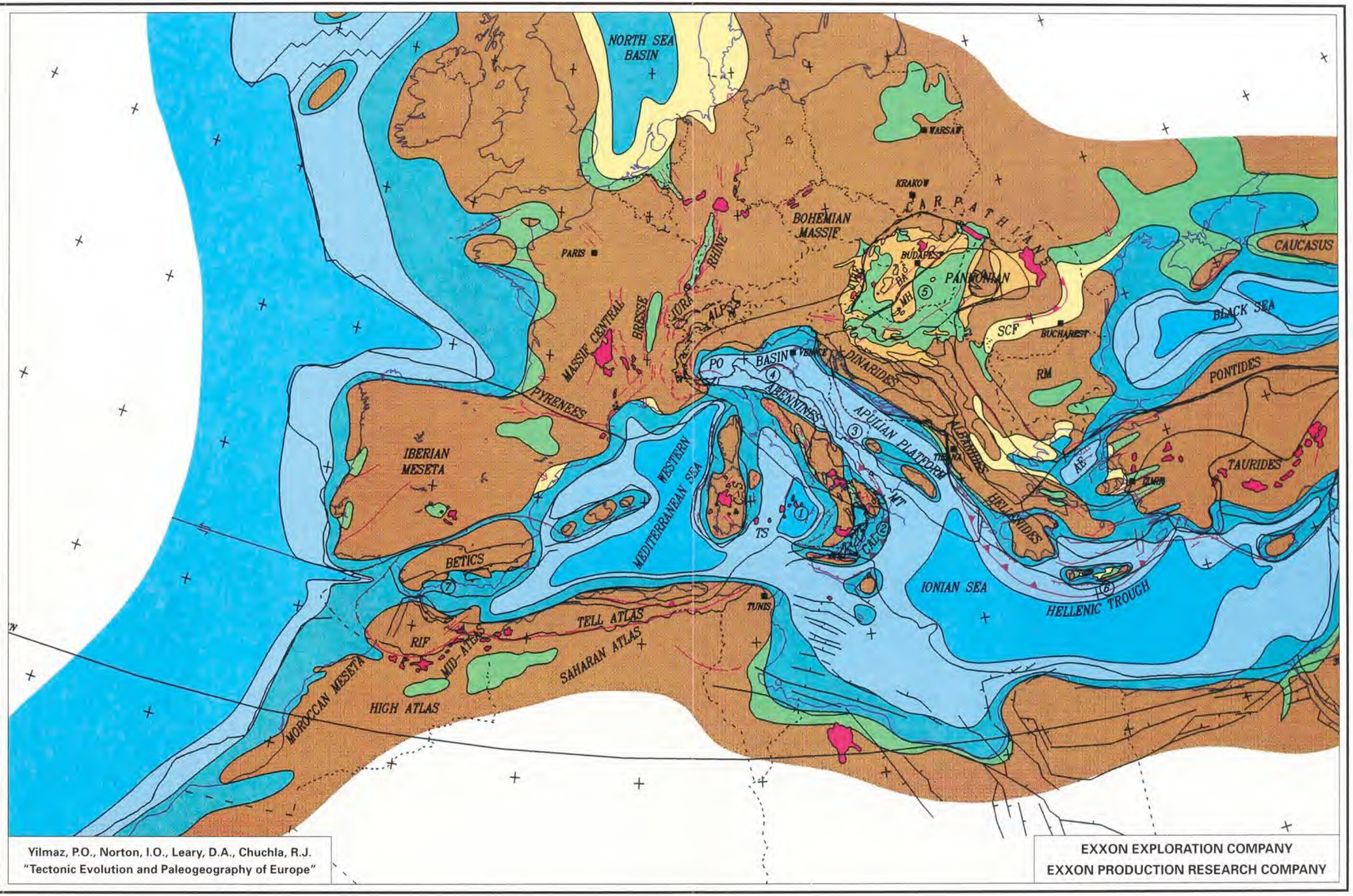
Yilmaz, P. O., Norton, I. O., Leary, D. & Chuchla, R. J., 1996. — Tectonic evolution and paleogeography of Europe. *In*: Ziegler, P. A. & Horváth, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. nain. Hist. nat.*, **170**: 47-60 + Enclosures 1-13. Paris ISBN: 2-85653-507-0.

OVERVIEW:

- The Alpine deformation front advanced northward and westward to the Jura and Western Alps, respectively.
- Compressional deformation and foredeep sedimentation continued in the Southern Carpathian, Apennine and Albanian systems.

FOOTNOTES:

1. Apennine subduction continued coeval with backarc extension and extensive magmatism in the Tyrrhenian Sea.
2. Apennine subduction was localized in the Calabrian area where part of the remaining Tethyan oceanic crust was being consumed.
3. The central and northern Apennine subduction boundary ceased completely in Quaternary time as thick continental crust of Apulia/Adriatic entered the subduction zone.
4. Subsidence caused by the Apennine subduction slab rollback beneath the Po basin accommodated 9 km of lower Pliocene and younger sediments.
5. Extension continued in the Pannonian basin while associated compression was restricted to the Carpathians. Present-Day Carpathian compression manifested by strong seismicity, is localized along the Vrancea zone. Regional extension led to exposure of high-grade metamorphic rocks of mid-crustal origin in Hungary.
6. Subduction along the Hellenic boundary and associated regional backarc extension in the Aegean continue to the present.
7. Alboran block collapses. Extension is dominant.



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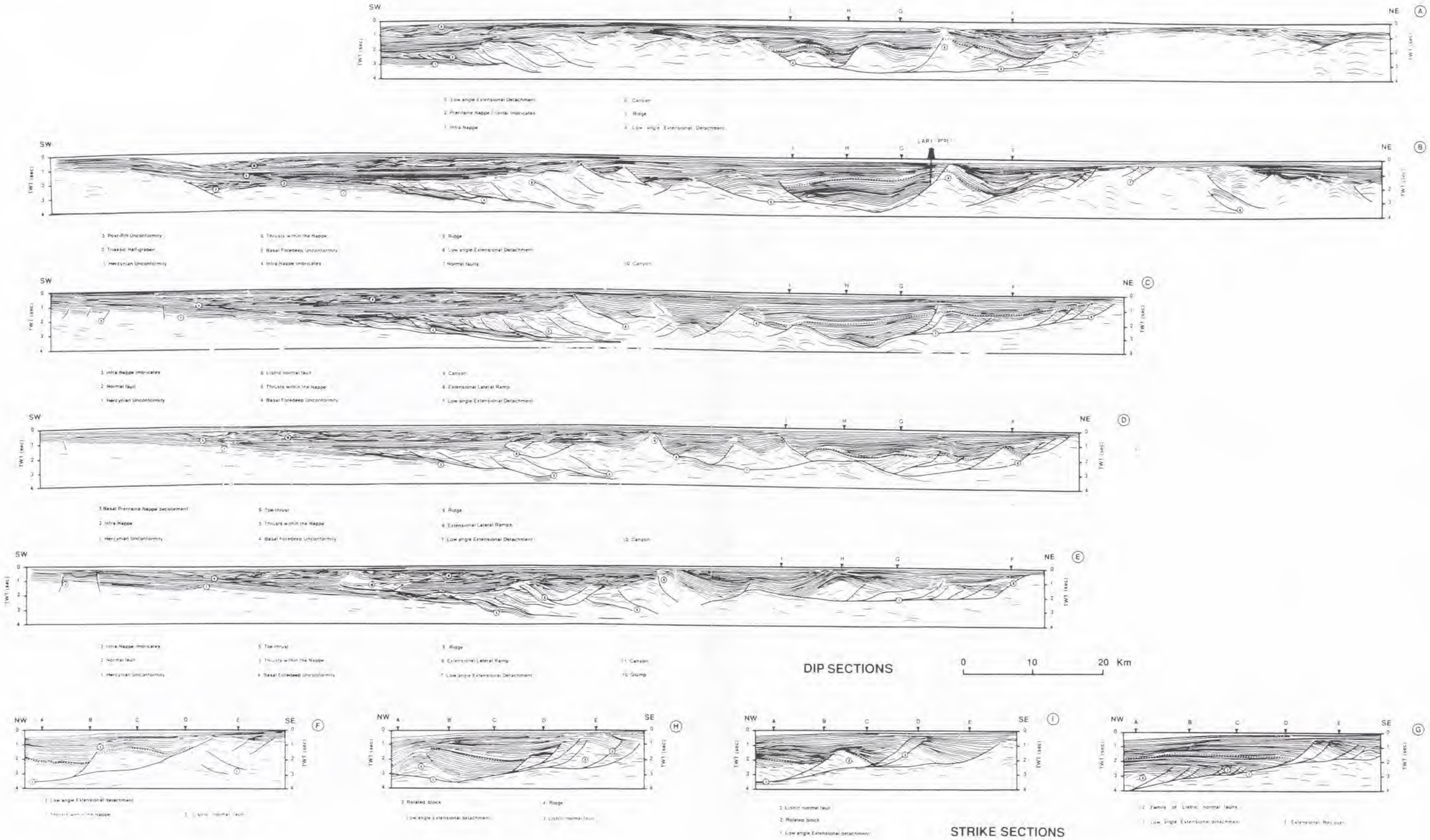

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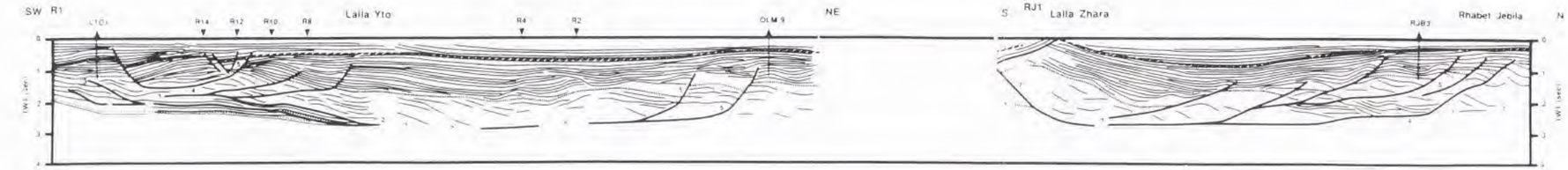
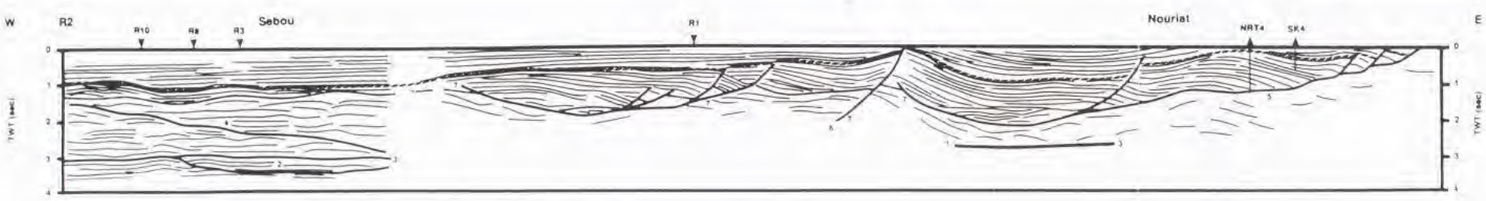
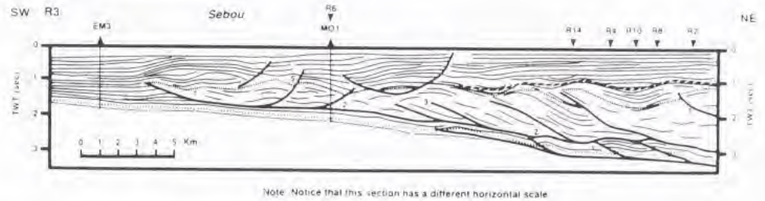
Enclosure 1

Source : MNHN, Paris







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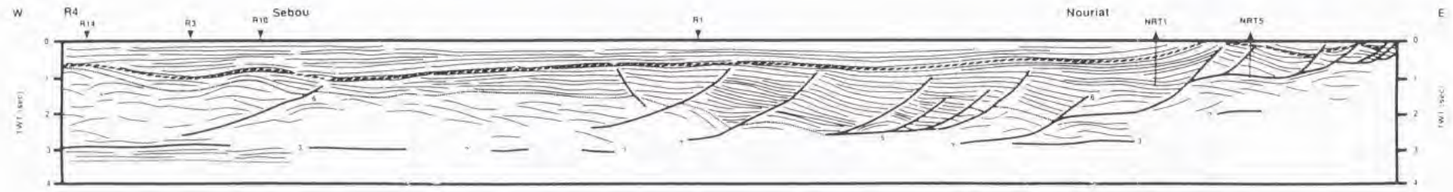

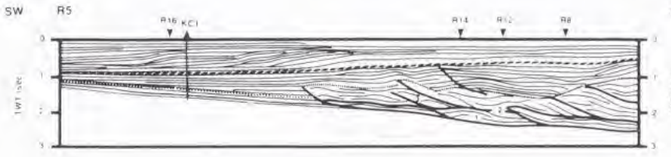

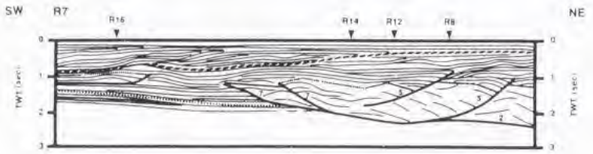

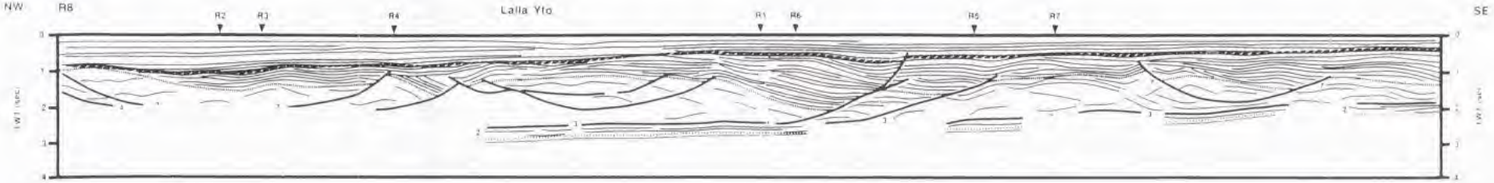

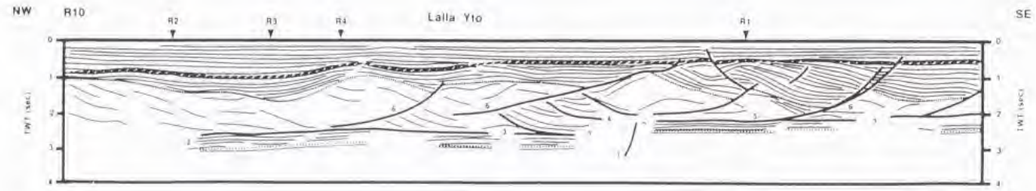

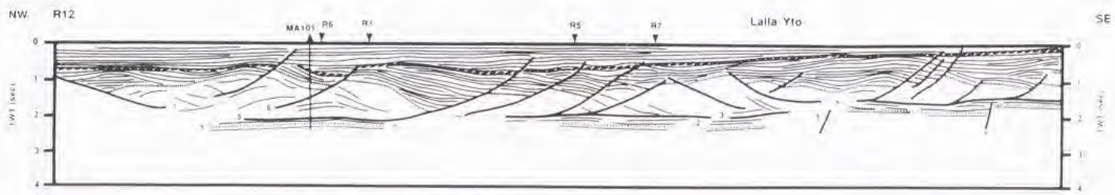

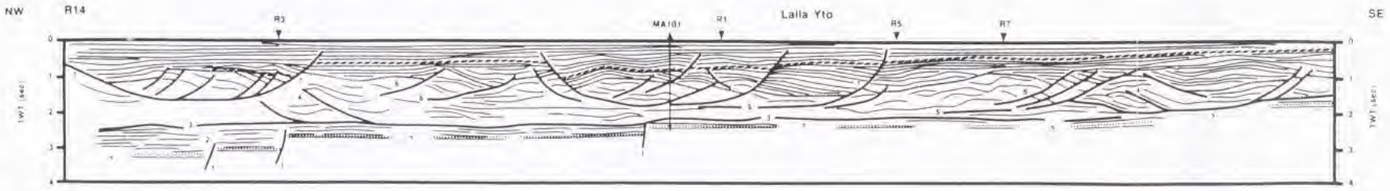

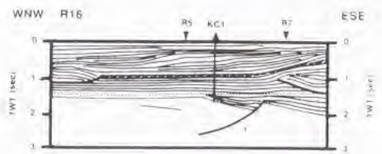

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Enclosure 2

BIBL DU MUSEUM PARIS

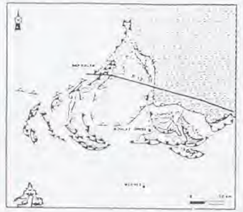
Source : MNHN, Paris

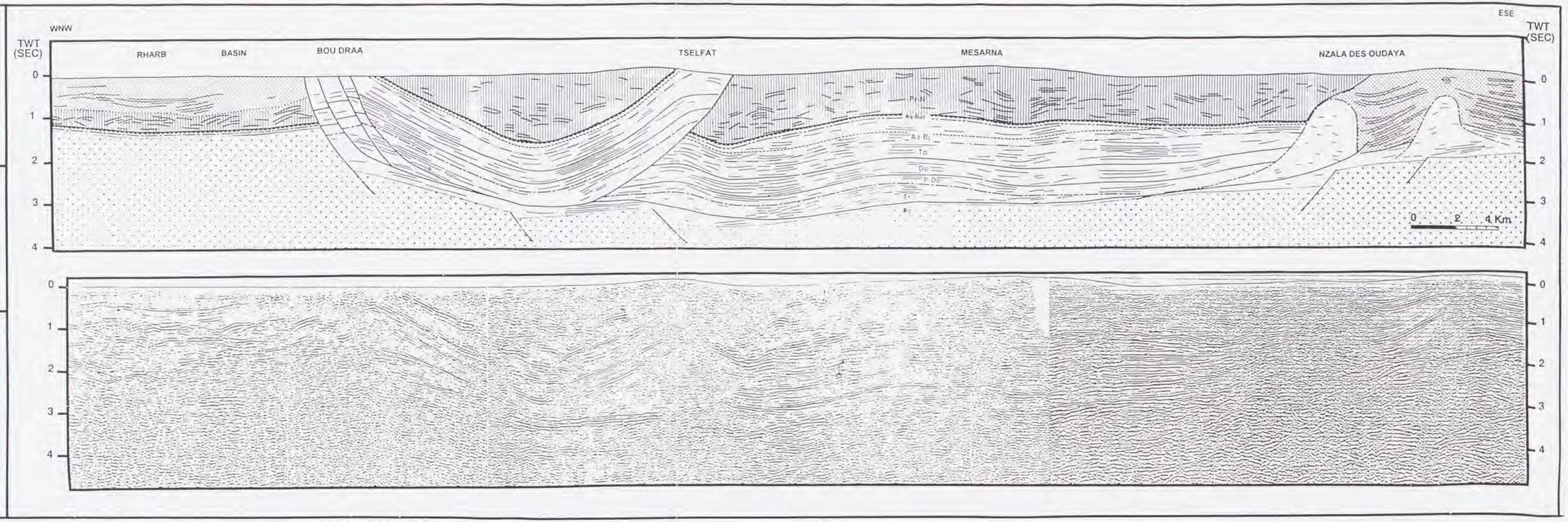
PLATE (1)

RIDES PRERIFAINES
LINE P 12

TOPS :

UM-PLI	: Upper Miocene - Pliocene
Pr-N	: Prerifaine Nappe
Aq-Bur	: AQUITANIAN-BURDIGALIAN
Aa-bj	: Aaleno - Bajocian
To	: Toarcian
Do	: Domerian
P-Do	: Pre - Domerian
Tr	: Triassic
Pz	: Paleozoic





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Enclosure 1

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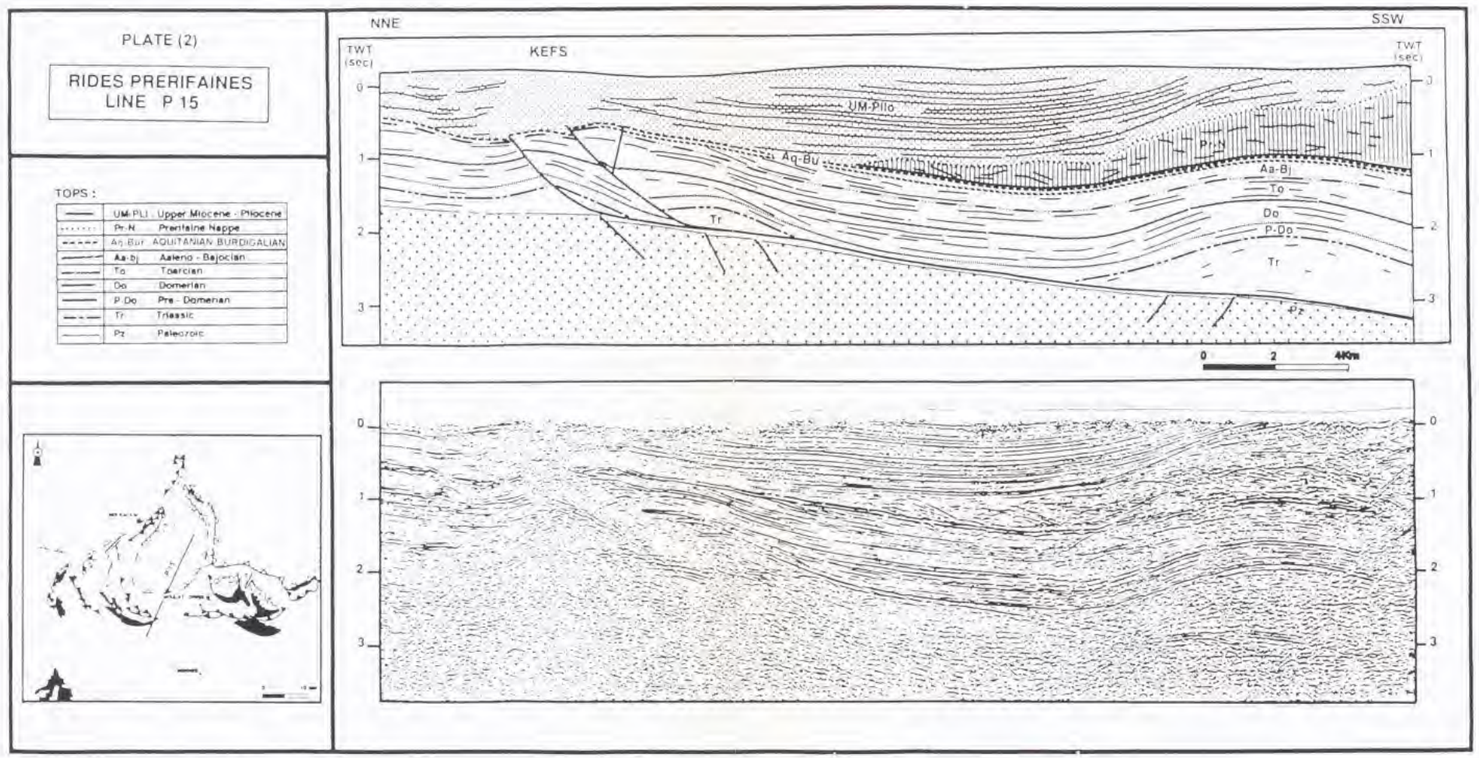

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Enclosure 2

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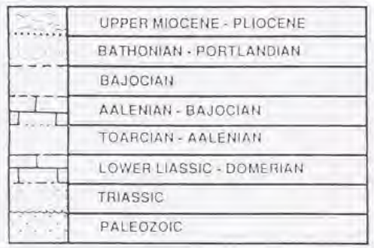
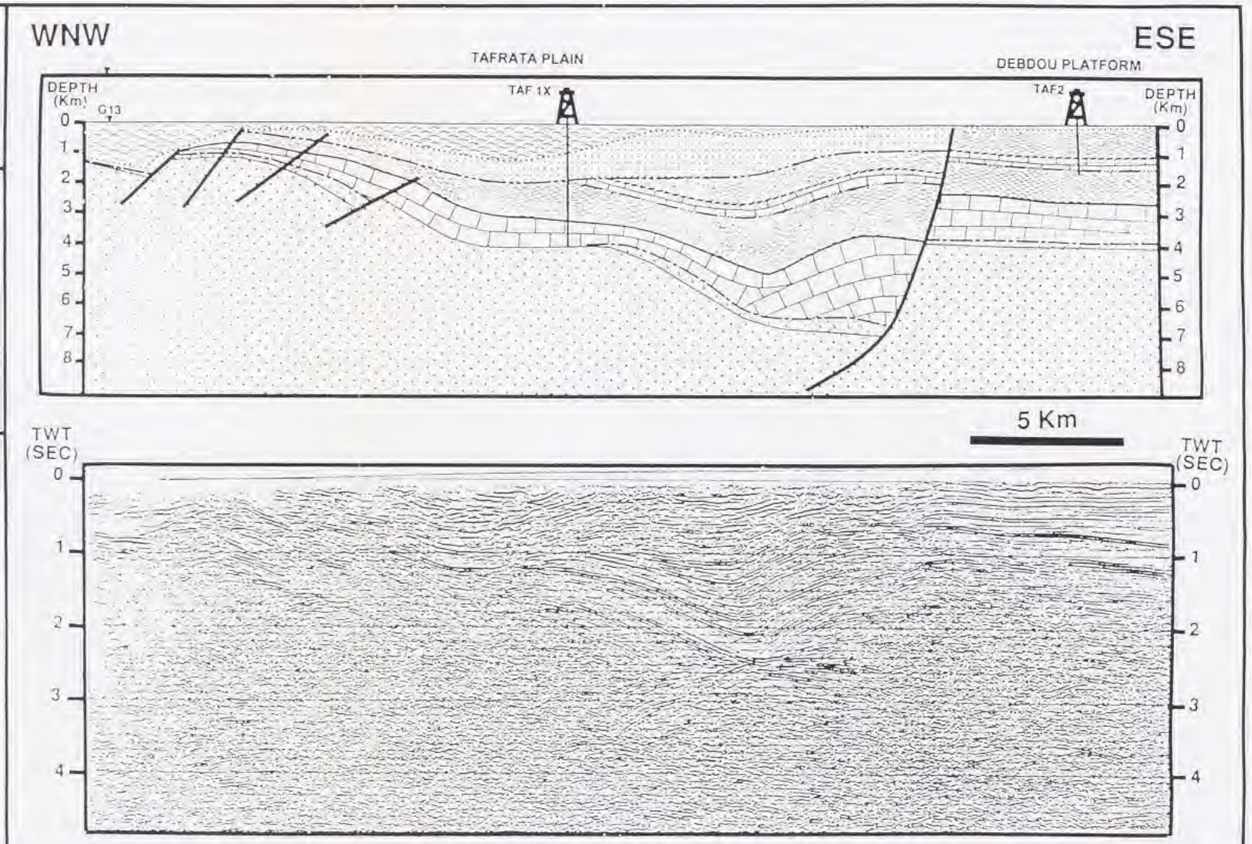
PLATE (3)

GUERCIF BASIN
LINE G17





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Enclosure 3

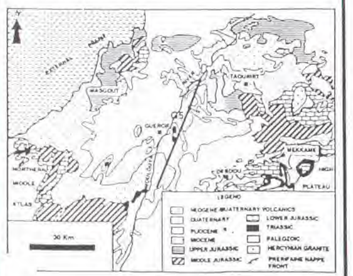
Source : MNHN, Paris

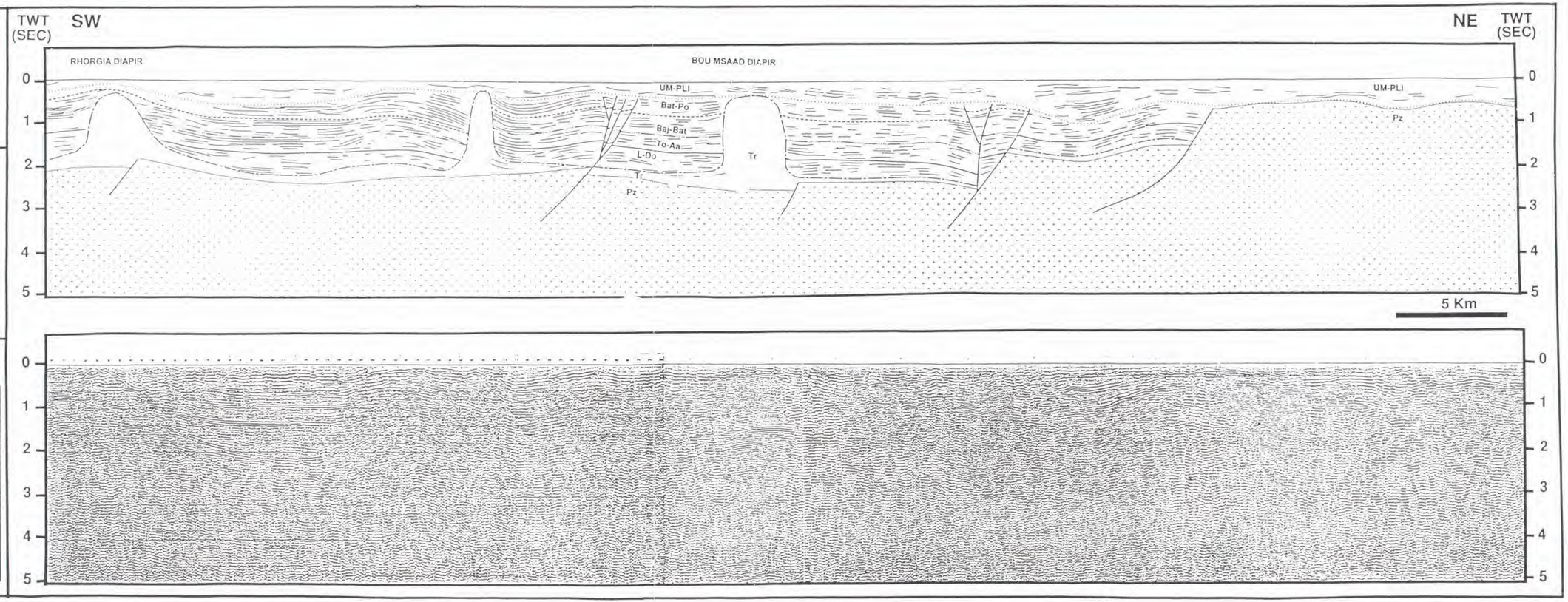
PLATE (4)

GUERCIF BASIN LINE G5

TOPS :

UM-PLI	: Upper Miocene - Pliocene
Bat - Po	: U.Bathonian - Portlandian
Baj-Bat	: Bajocian - Bathonian
To-Aa	: Toarcian - Aalenian
L-Do	: Lower Liassic - Domerian
Tr	: Triassic
Pz	; Paleozoic





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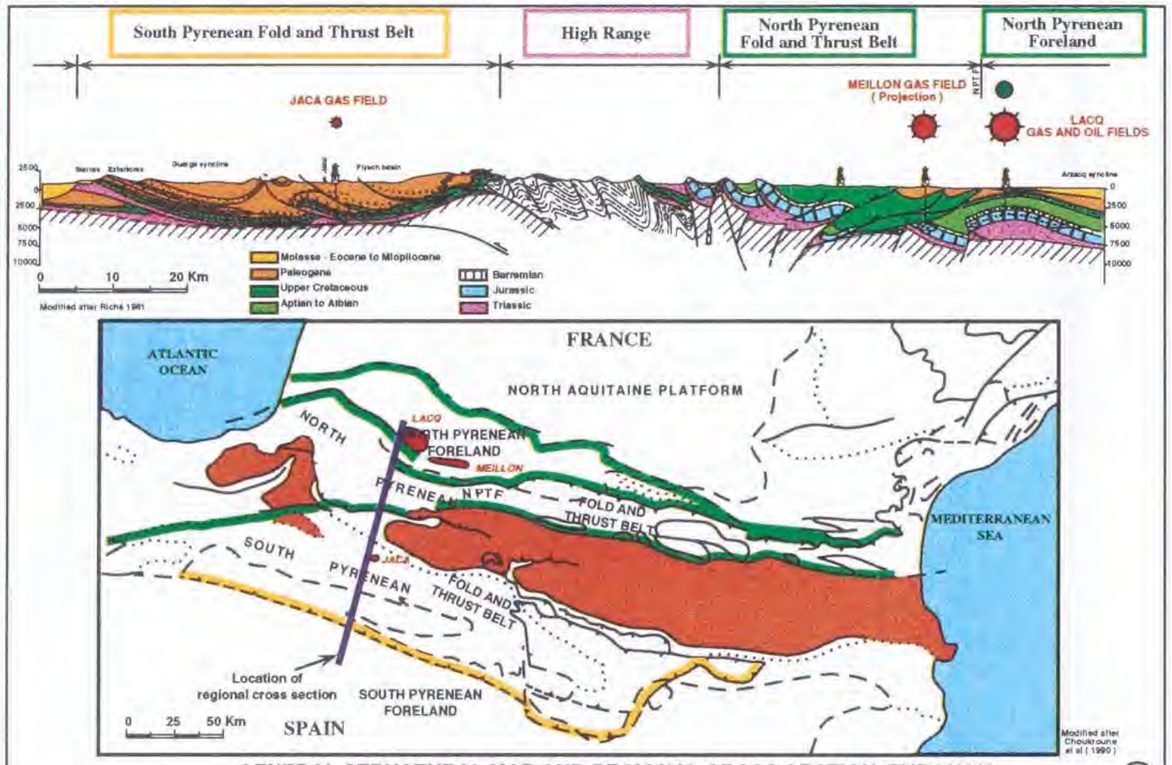
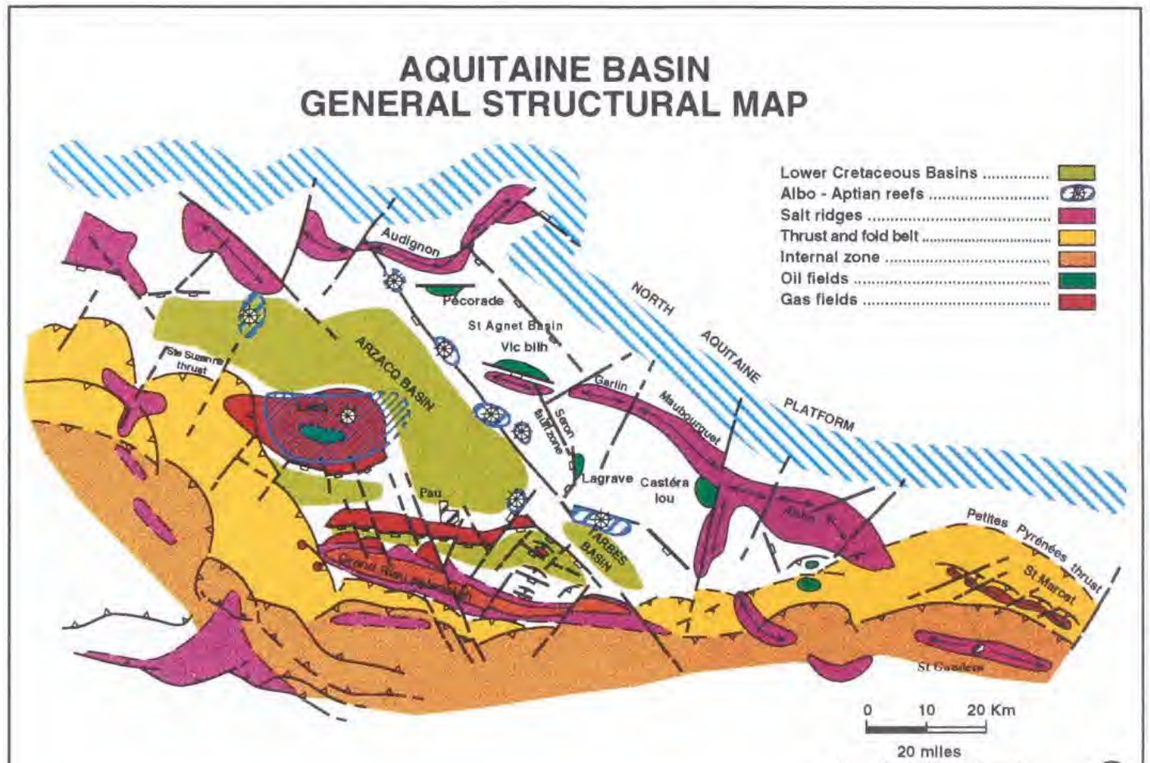
Source : MNHN, Paris

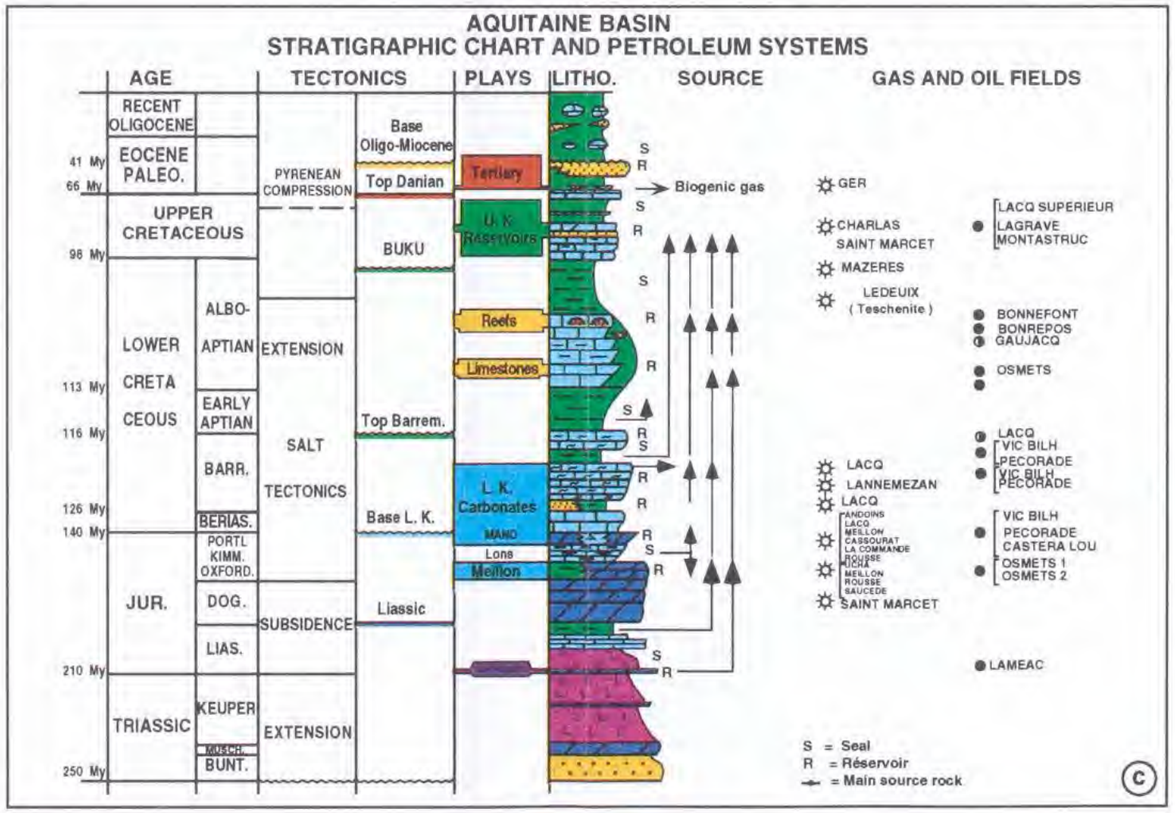


GENERAL STRUCTURAL MAP AND REGIONAL CROSS SECTION THROUGH THE PYRENEAN MOUNTAIN CHAIN .

(a)



(b)



(c)

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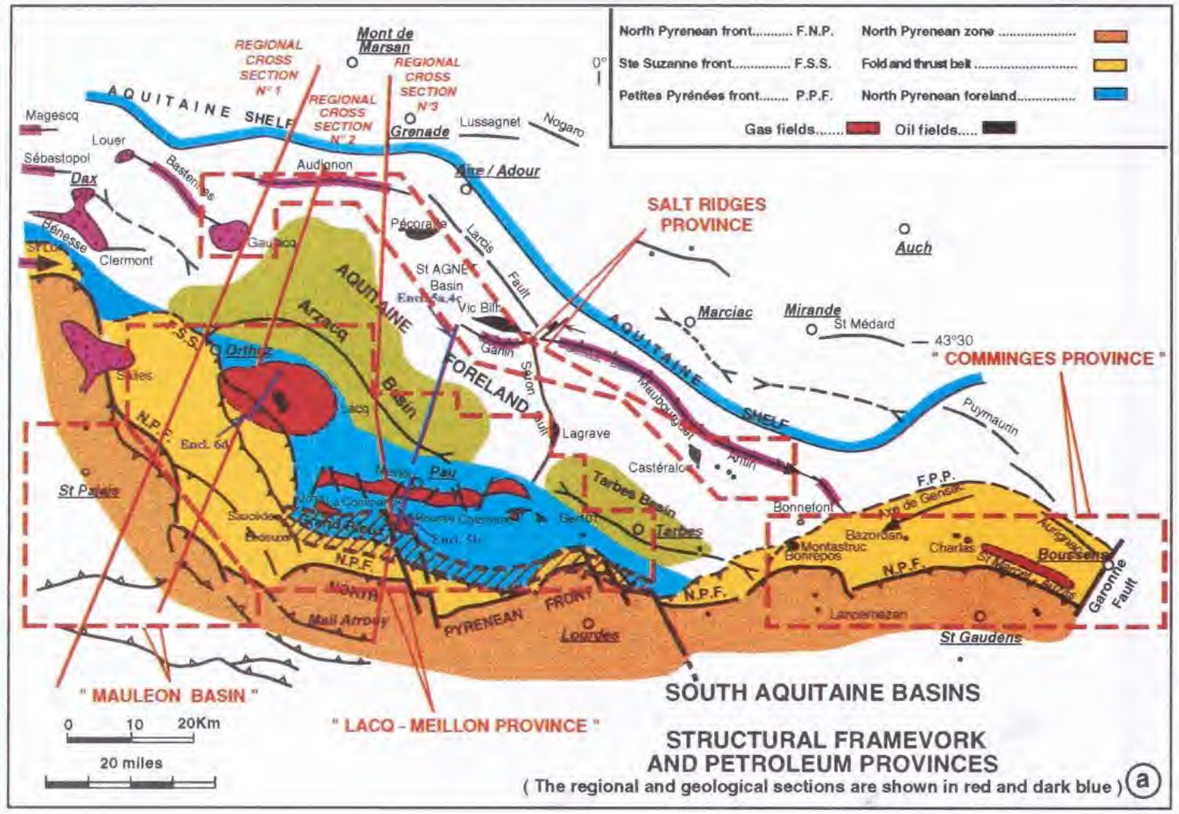
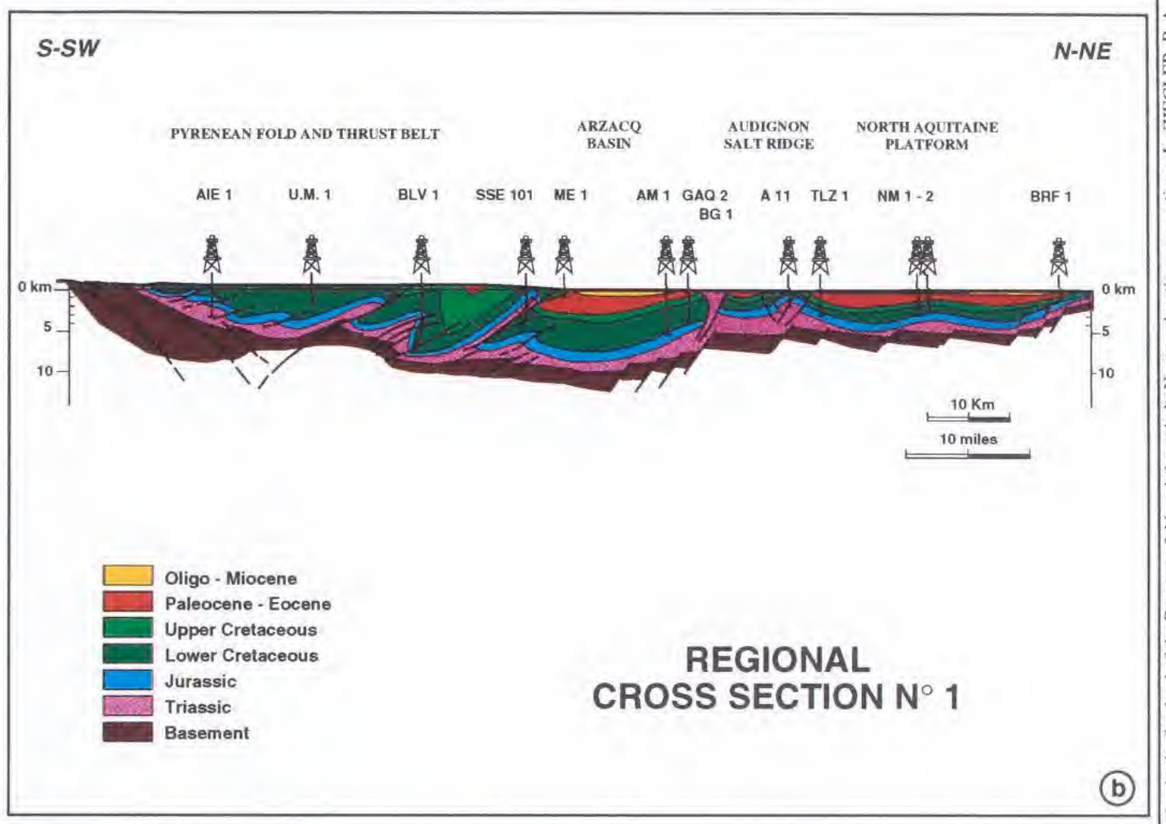
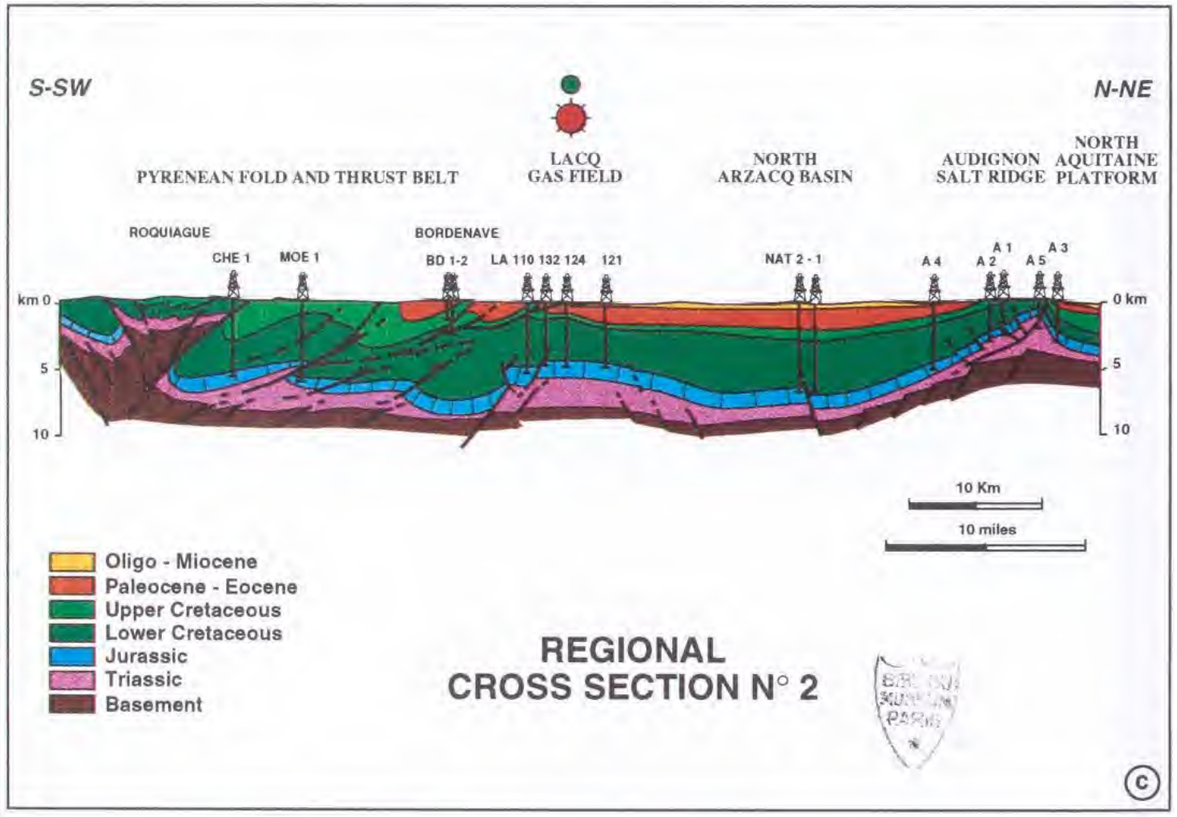
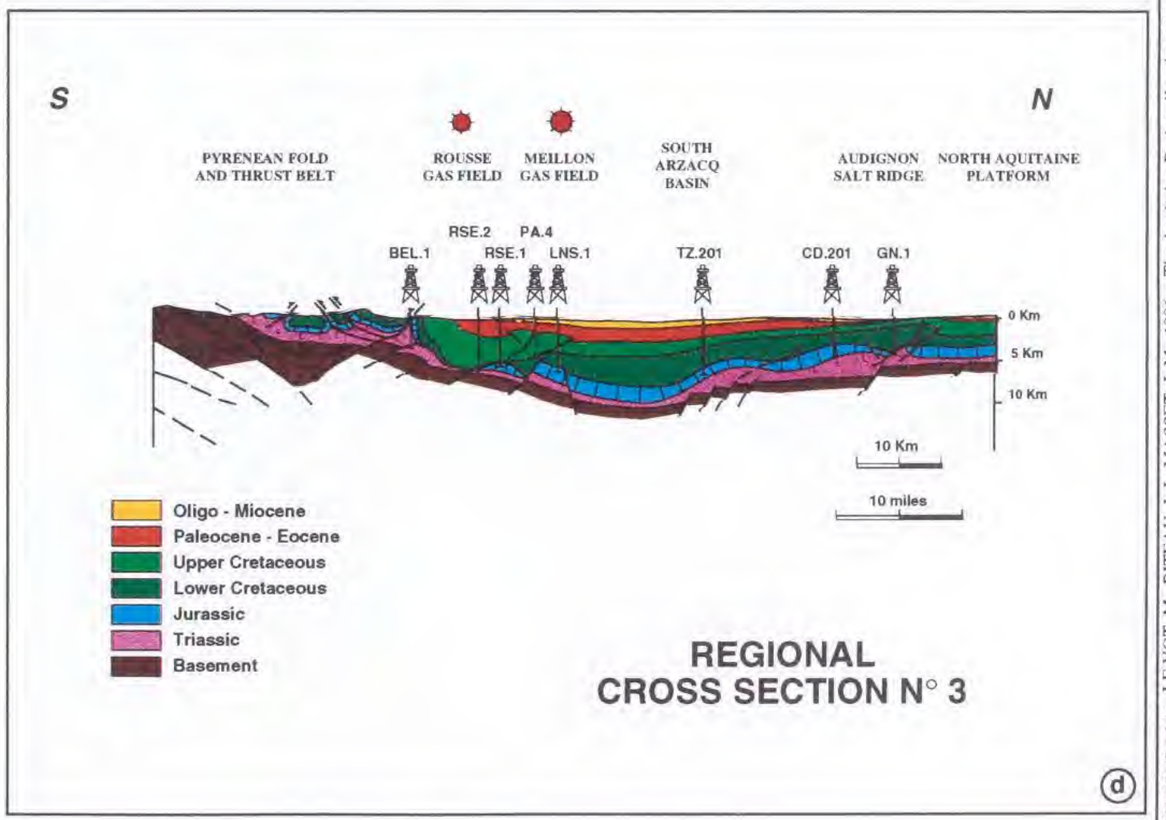
ENCLOSURE N°1 LE VOT, M., BITEAU, J. J., MASSET, J. M., 1996. - The Aquitaine Basin: oil and gas production in the foreland of the Pyrenean fold-and-thrust belt. New exploration perspectives. *In*: ZIEGLER, P. A. & HORVATH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and forelands. *Mém. Mus. natn. Hist. Nat.*, **170**: 159-171 + Enclosures 1-6. Paris ISBN: 2-85653-507-0.

Source : MNHN, Paris









ENCLOSURE N°2 LE VOT, M., BITEAU, J. J., MASSET, J. M., 1996. - The Aquitaine Basin: oil and gas production in the foreland of the Pyrenean fold-and-thrust belt. New exploration perspectives. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and forelands. *Mém. Mus. natn. Hist. Nat.*, **170**: 159-171 + Enclosures 1-6. Paris ISBN: 2-85653-507-0.

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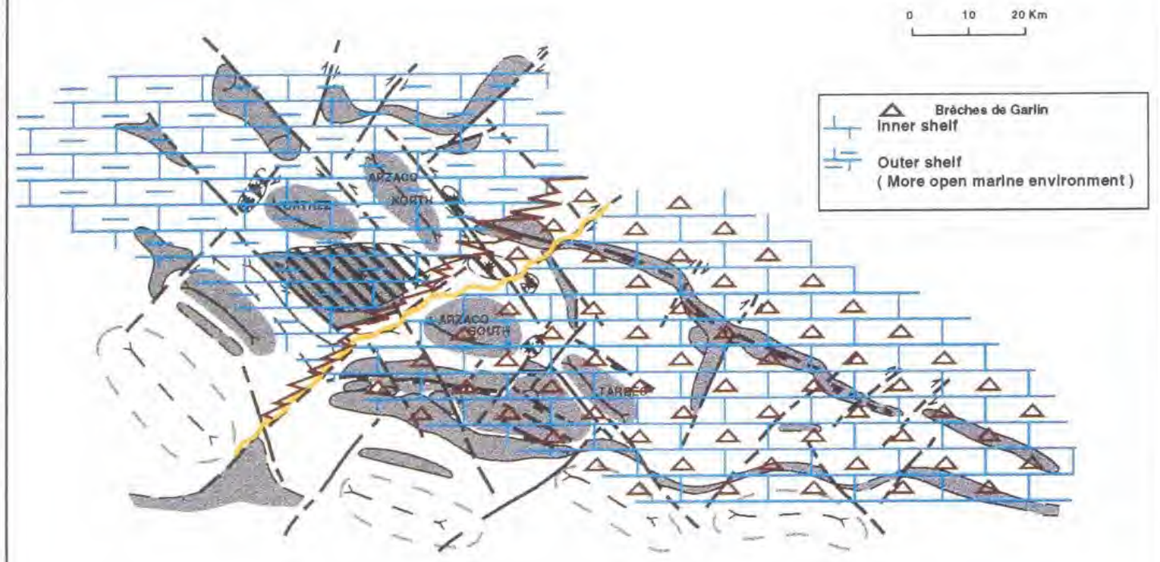
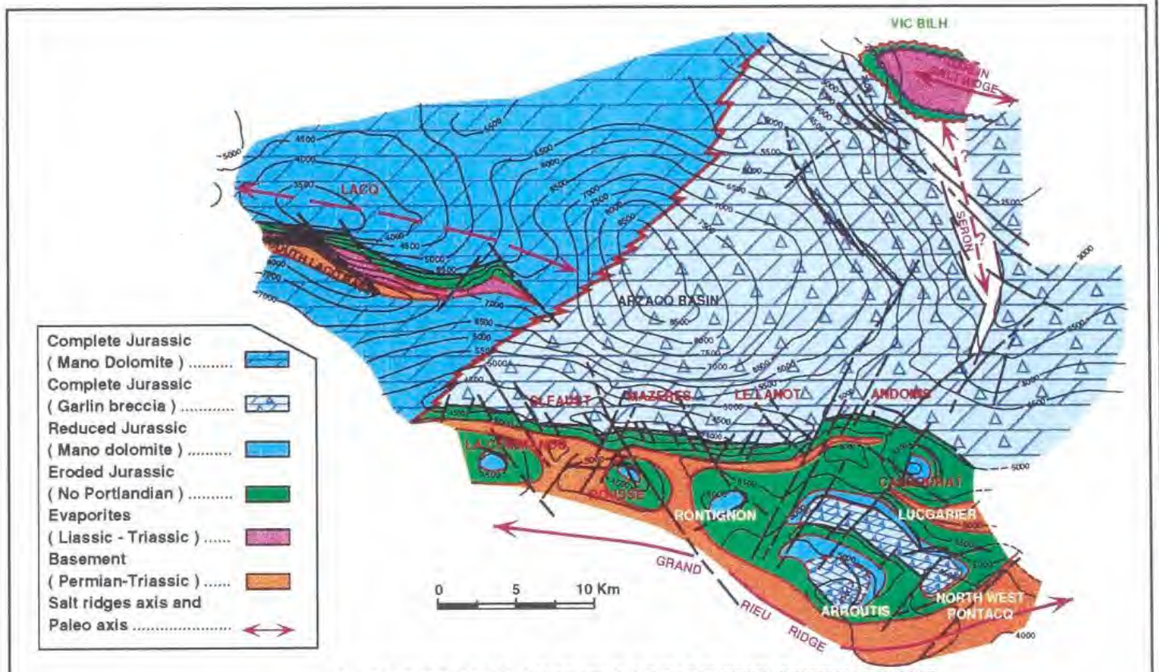


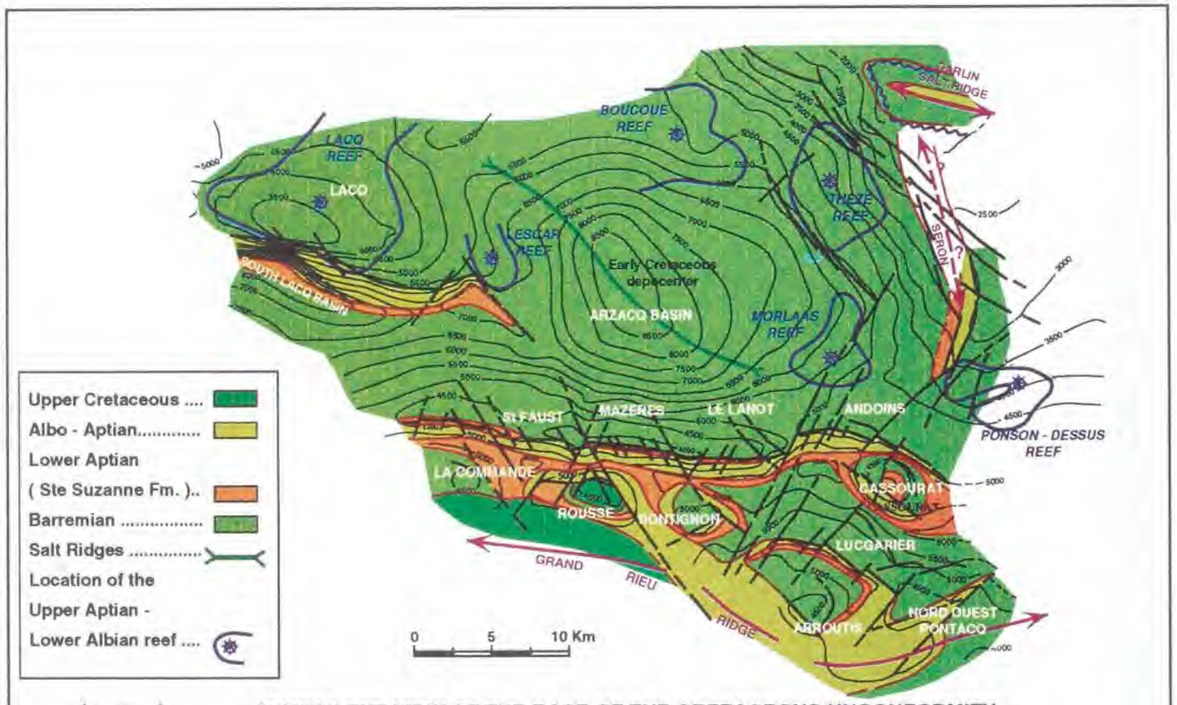
GENERAL PALEOGEOGRAPHIC MAP OF THE AQUITAINE BASIN
AT THE END OF THE EARLY KIMMERIDGIAN
(THIS MAP IS BASED ON THE AVAILABLE WELL CONTROL)

(a)



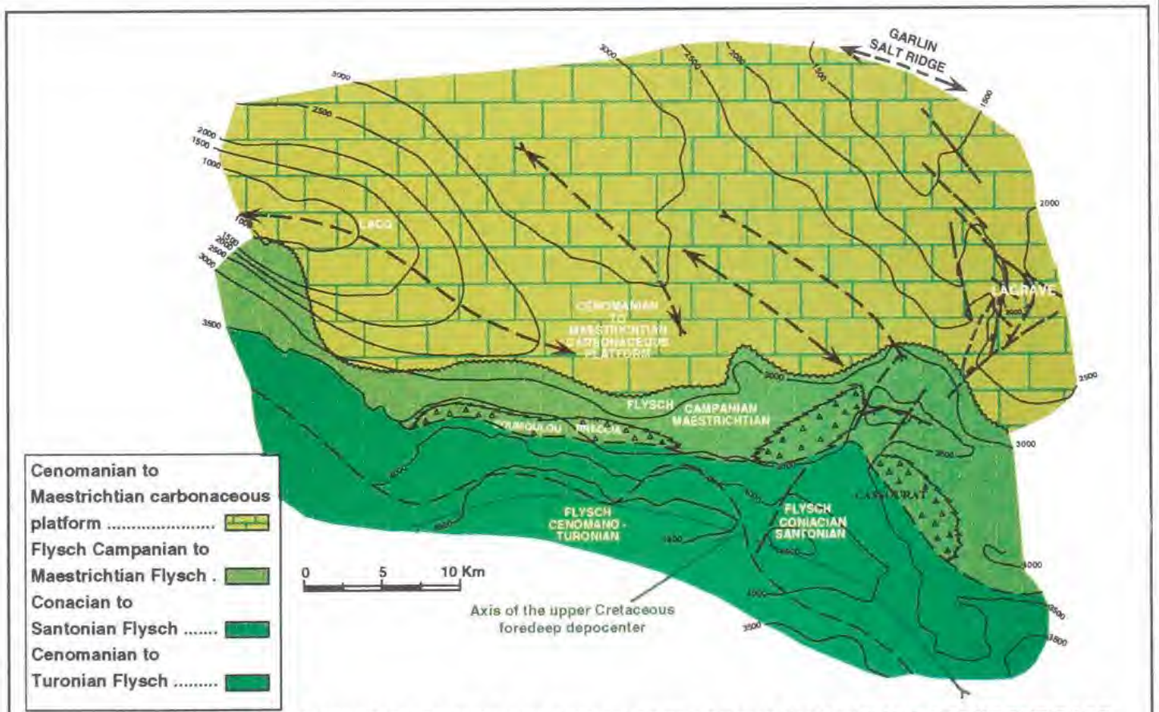
SUBCROP MAP AT THE BASE OF THE CRETACEOUS
SHOWING THE PALEOGEOGRAPHY OF THE PORTLANDIAN AS WELL AS
THE EROSION DUE TO SALT TECTONICS ALONG THE EDGES OF THE ARZACQ BASIN
NOTE THE STRUCTURAL STYLES AND POSITION OF THE FIELDS WITHIN THE GENERAL CONTEXT
(Depth contours at Base Cretaceous unconformity in meters)

(b)



WORM'S EYE VIEW AT THE BASE OF THE CRETACEOUS UNCONFORMITY .
IT CLEARLY DEMONSTRATES THE IMPORTANCE OF SALT TECTONICS DURING
THE EARLY MOST CRETACEOUS TIMES ALONG THE EDGES OF THE CONTEMPORANEOUS
SUBSIDING DEPOCENTERS
(Depth contours at Base Cretaceous unconformity in meters)

(c)



MAP SHOWING THE DISTRIBUTION OF THE UPPER CRETACEOUS FORMATIONS ABOVE THE BASE
OF UPPER CRETACEOUS UNCONFORMITY .
NOTE THE NORTHWARD MIGRATION OF THE FOREDEEP FROM THE CENOMANIAN TO THE MAESTRICHTIAN .
(Depth contours of Base Cretaceous unconformity in meters)

(d)

ENCLOSURE N°3 LE VOT, M., BITEAU, J. J., MASSET, J. M., 1996. - The Aquitaine Basin: oil and gas production in the foreland of the Pyrenean fold-and-thrust belt. New exploration perspectives. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and forelands. *Mém. Mus. natn. Hist. Nat.*, **170**: 159-171 + Enclosures 1-6, Paris ISBN: 2-85653-507-0.

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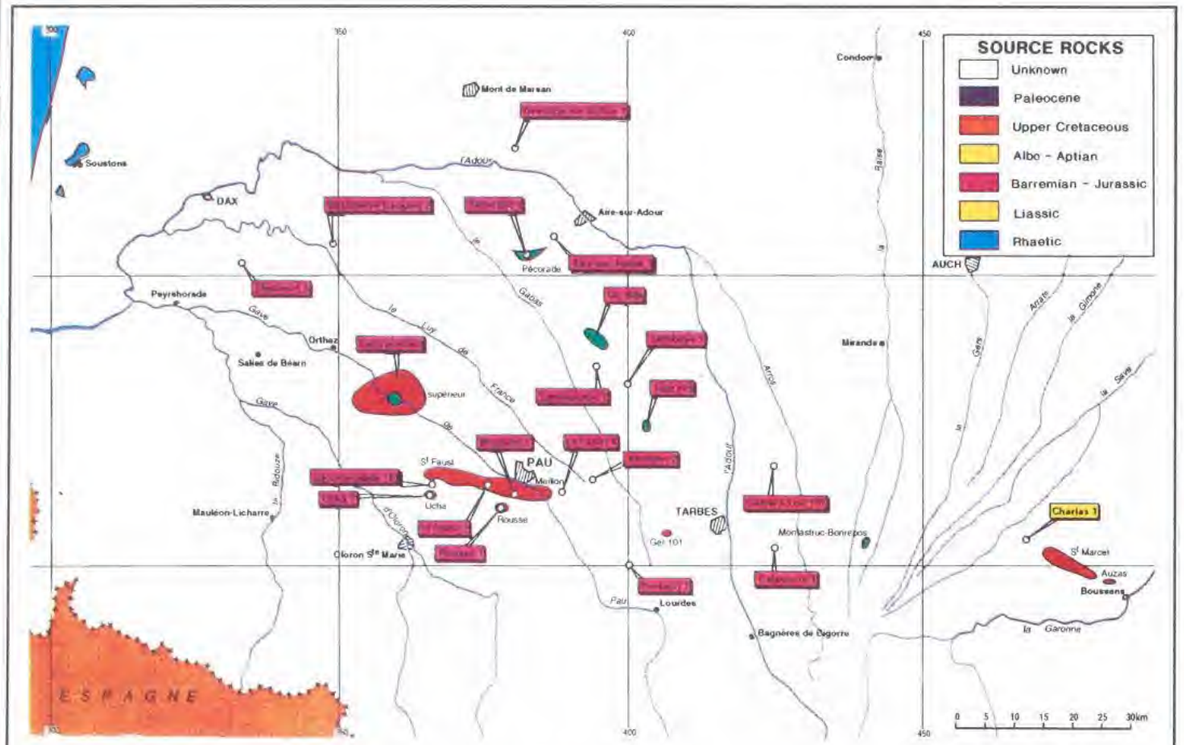
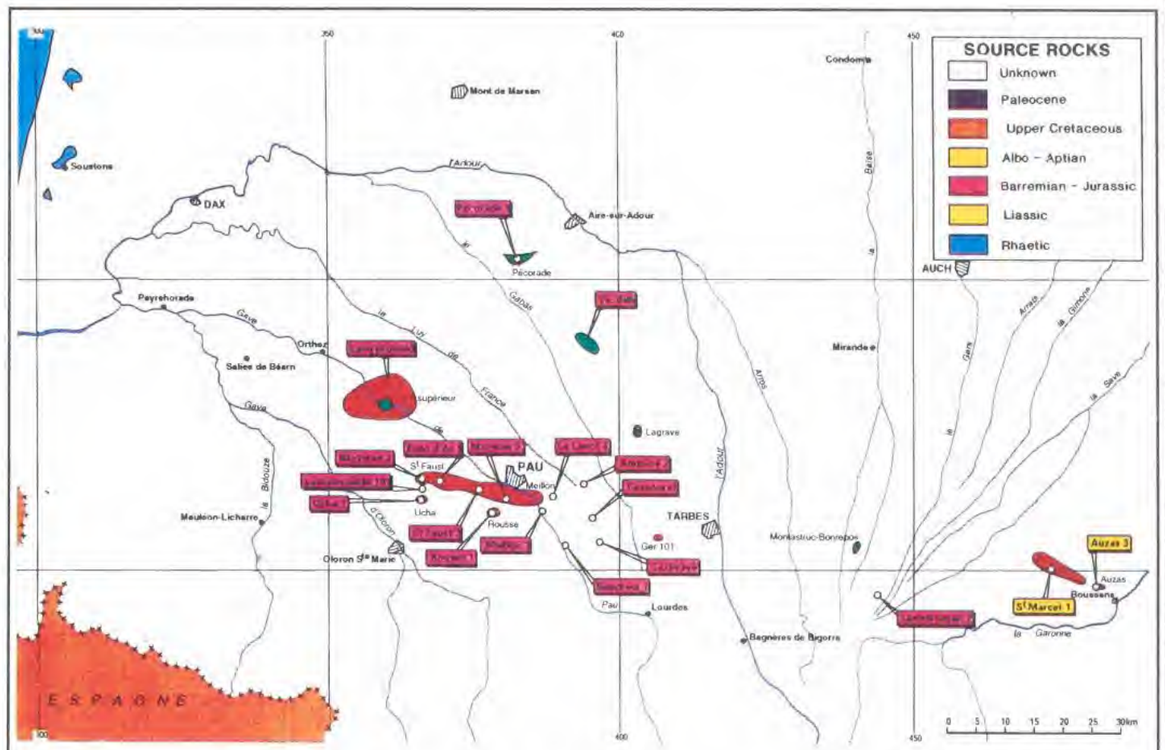
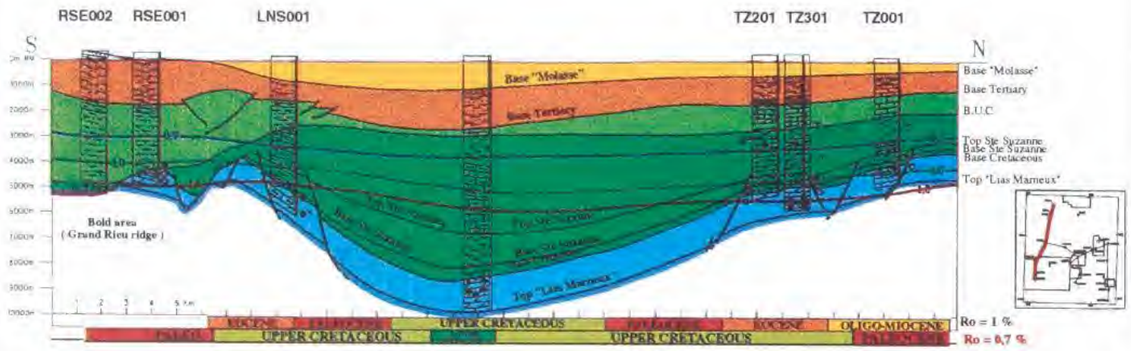


OIL TO SOURCE CORRELATIONS IN THE AQUITAINE BASIN (a)

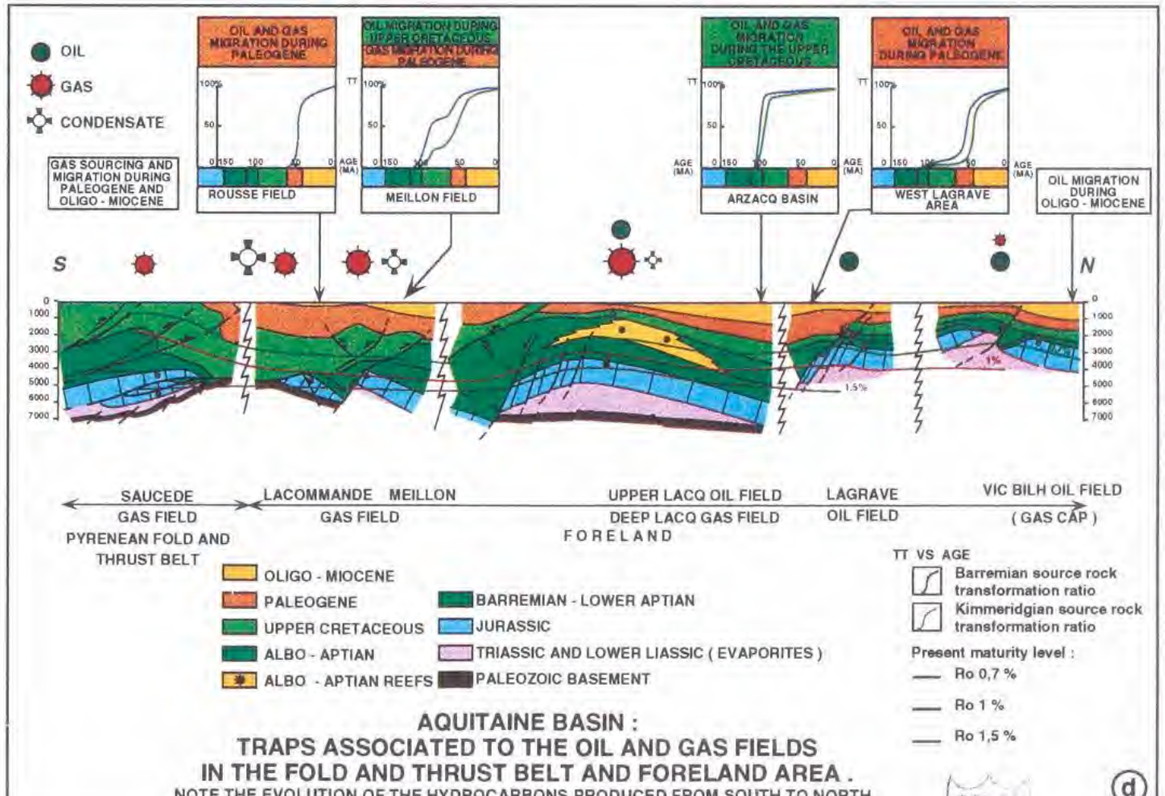


GAS TO SOURCE CORRELATIONS IN THE AQUITAINE BASIN (b)



GENERAL CROSS SECTION THROUGH THE ARZACQ BASIN SHOWING THE TIMING OF GENERATION AND MIGRATION OF HYDROCARBONS IN THE AREA AS WELL AS THE ISOMATURATION LEVELS .

(c)



AQUITAINE BASIN :
TRAPS ASSOCIATED TO THE OIL AND GAS FIELDS IN THE FOLD AND THRUST BELT AND FOREland AREA .
NOTE THE EVOLUTION OF THE HYDROCARBONS PRODUCED FROM SOUTH TO NORTH .

(d)

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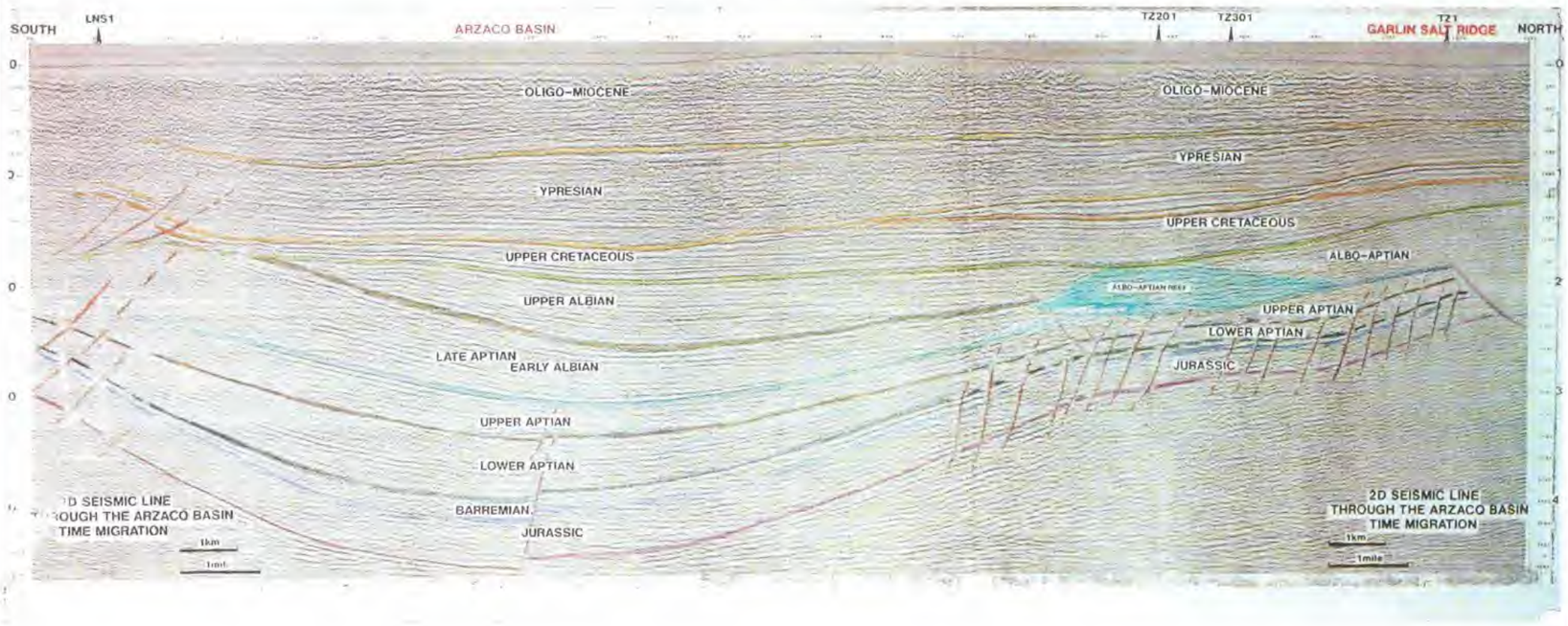
ENCLOSURE N°4 LE VOT, M., BITEAU, J. J., MASSET, J. M., 1996. - The Aquitaine Basin: oil and gas production in the foreland of the Pyrenean fold-and-thrust belt. New exploration perspectives. *In:* ZIEGLER, P. A. & HORVATH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and forelands. *Mém. Mus. natn. Hist. Nat.*, **170**: 159-171 + Enclosures 1-6, Paris ISBN: 2-85653-507-0.

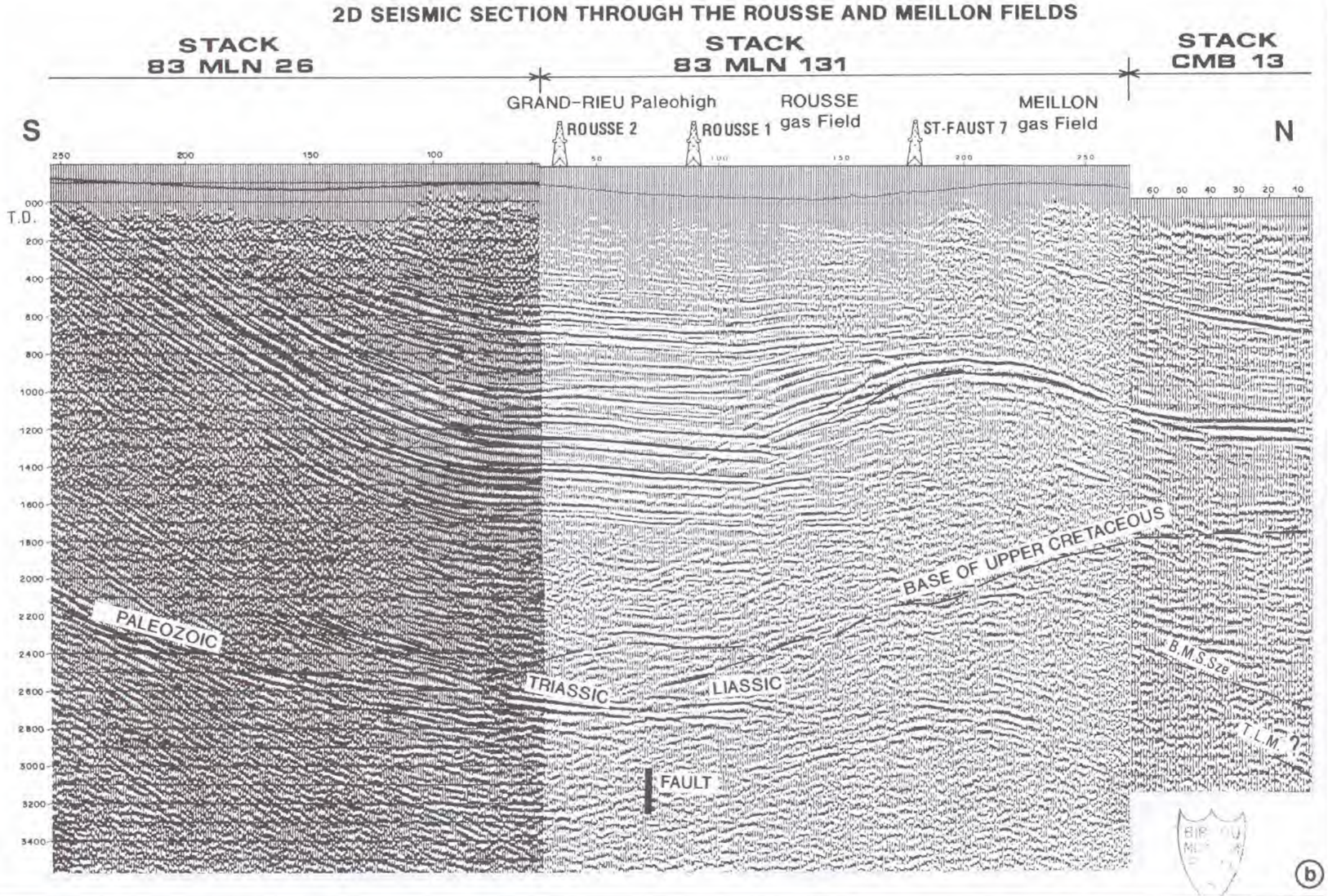
Source : MNHN, Paris

2D SEISMIC LINE THROUGH THE ARZACQ BASIN TIME MIGRATION
(82 SVG 9)



(a)

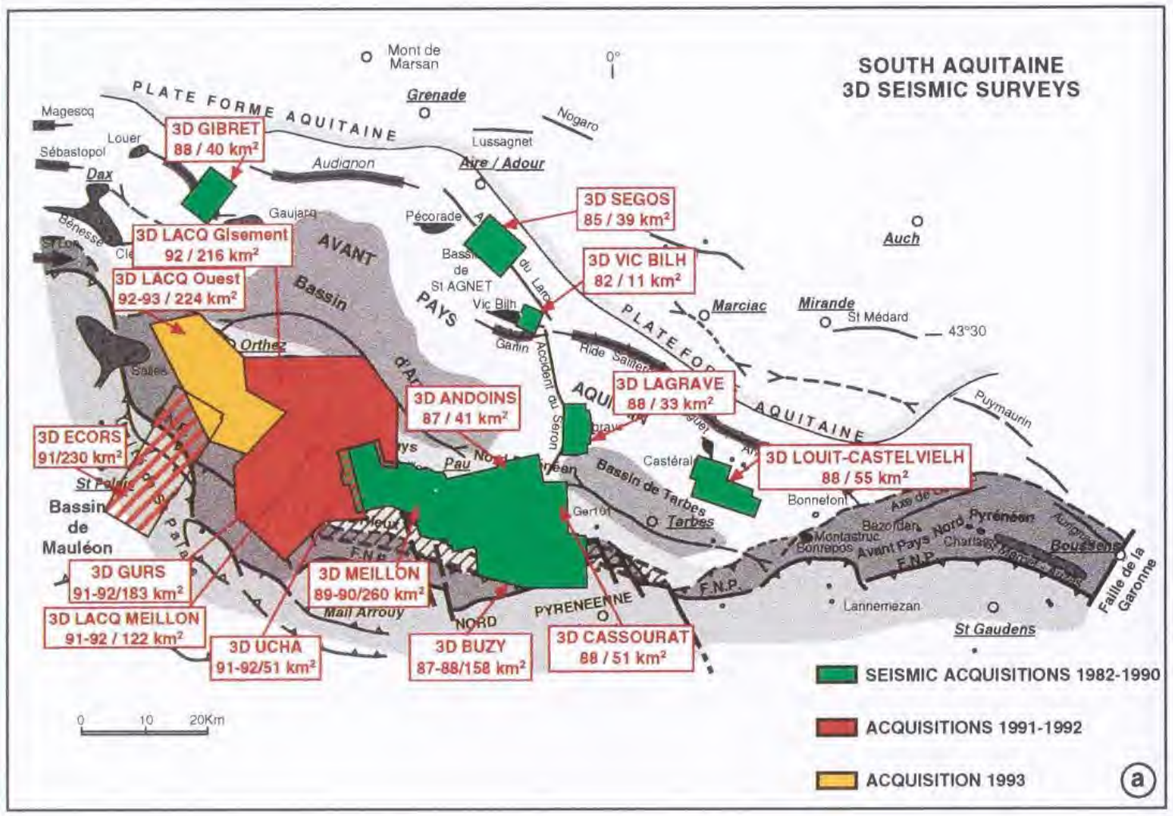
2D SEISMIC SECTION THROUGH THE ROUSSE AND MEILLON FIELDS

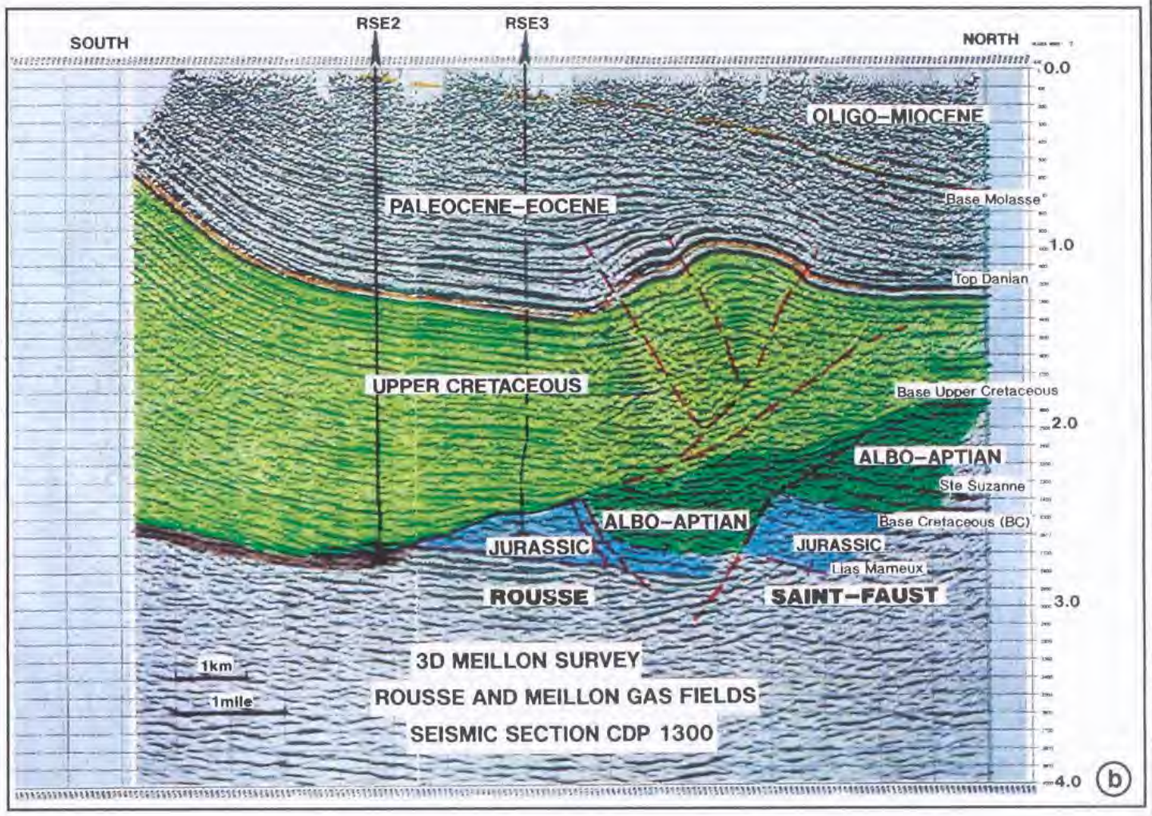


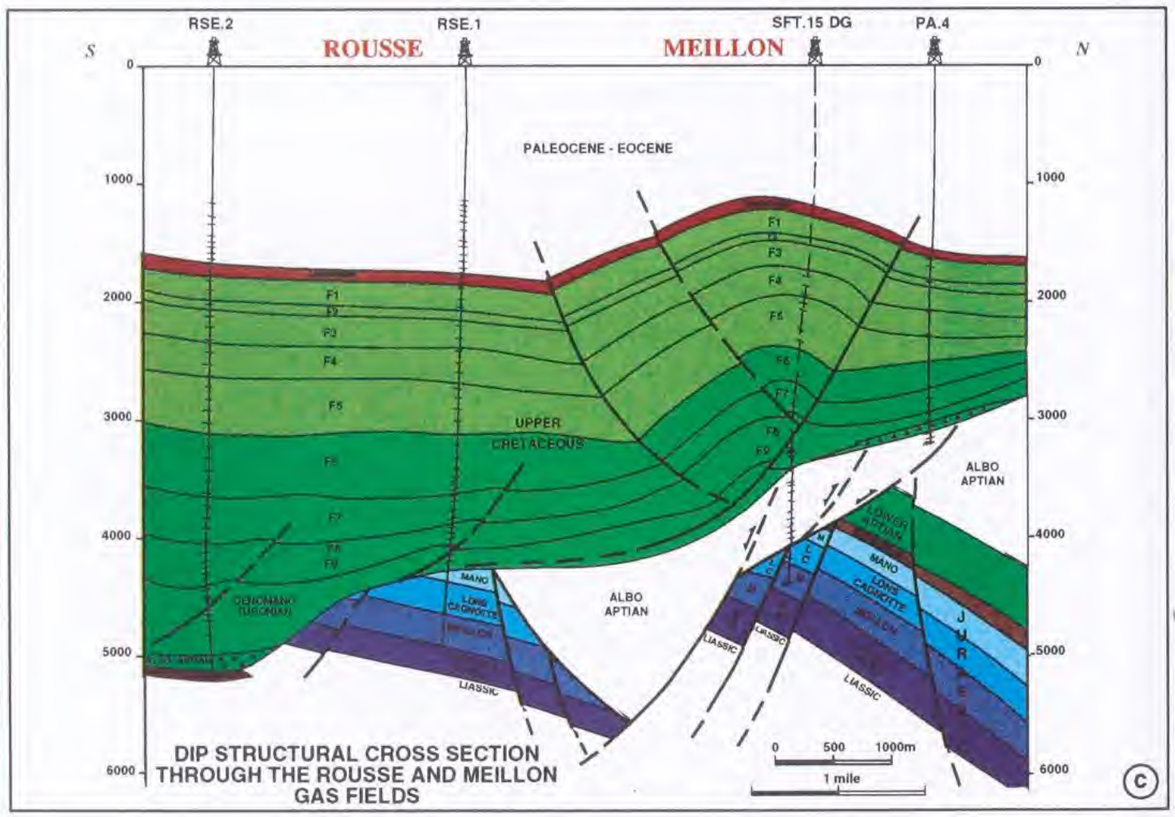
(b)

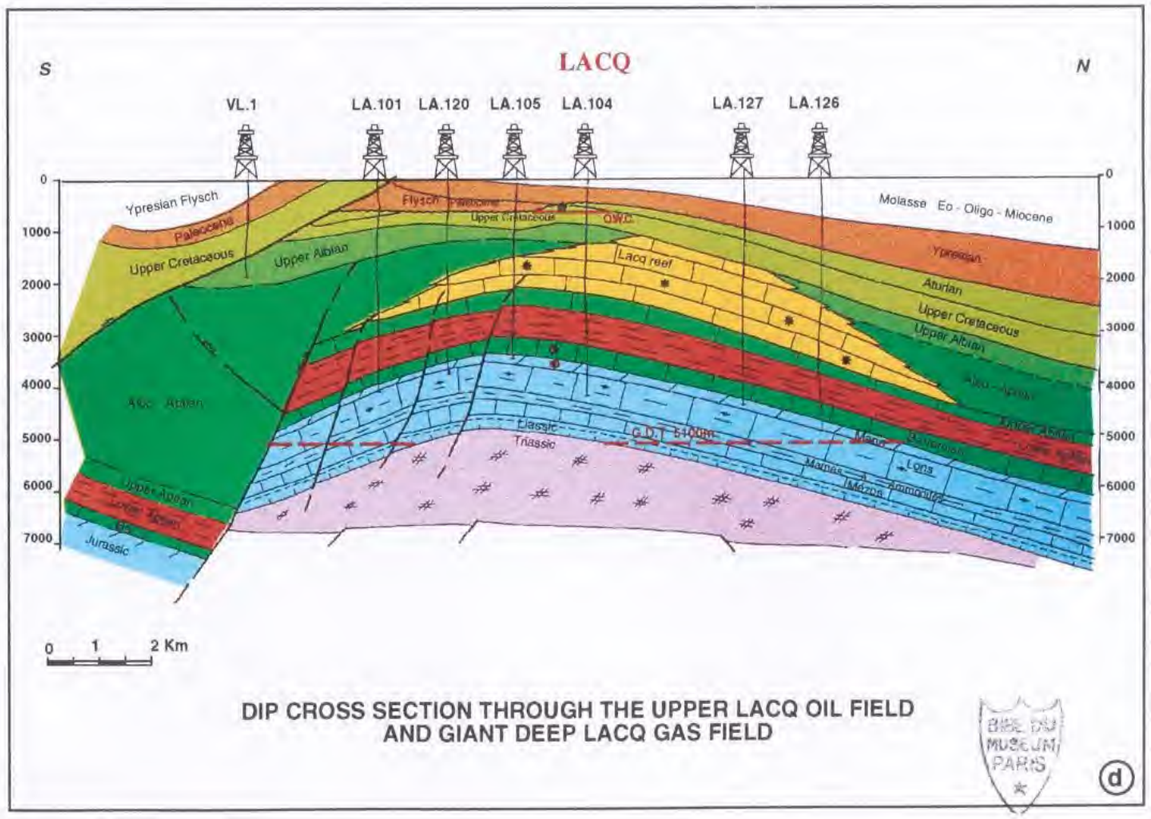
ENCLOSURE N°5 LE VOT, M., BITEAU, J. J., MASSET, J. M., 1996. - The Aquitaine Basin: oil and gas production in the foreland of the Pyrenean fold-and-thrust belt. New exploration perspectives. *In*: ZIEGLER, P. A. & HORVÀTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and forelands. *Mém. Mus. natn. Hist. Nat.*, **170**: 159-171 + Enclosures 1-6. Paris ISBN: 2-85653-507-0.

Source: MNHN, Paris









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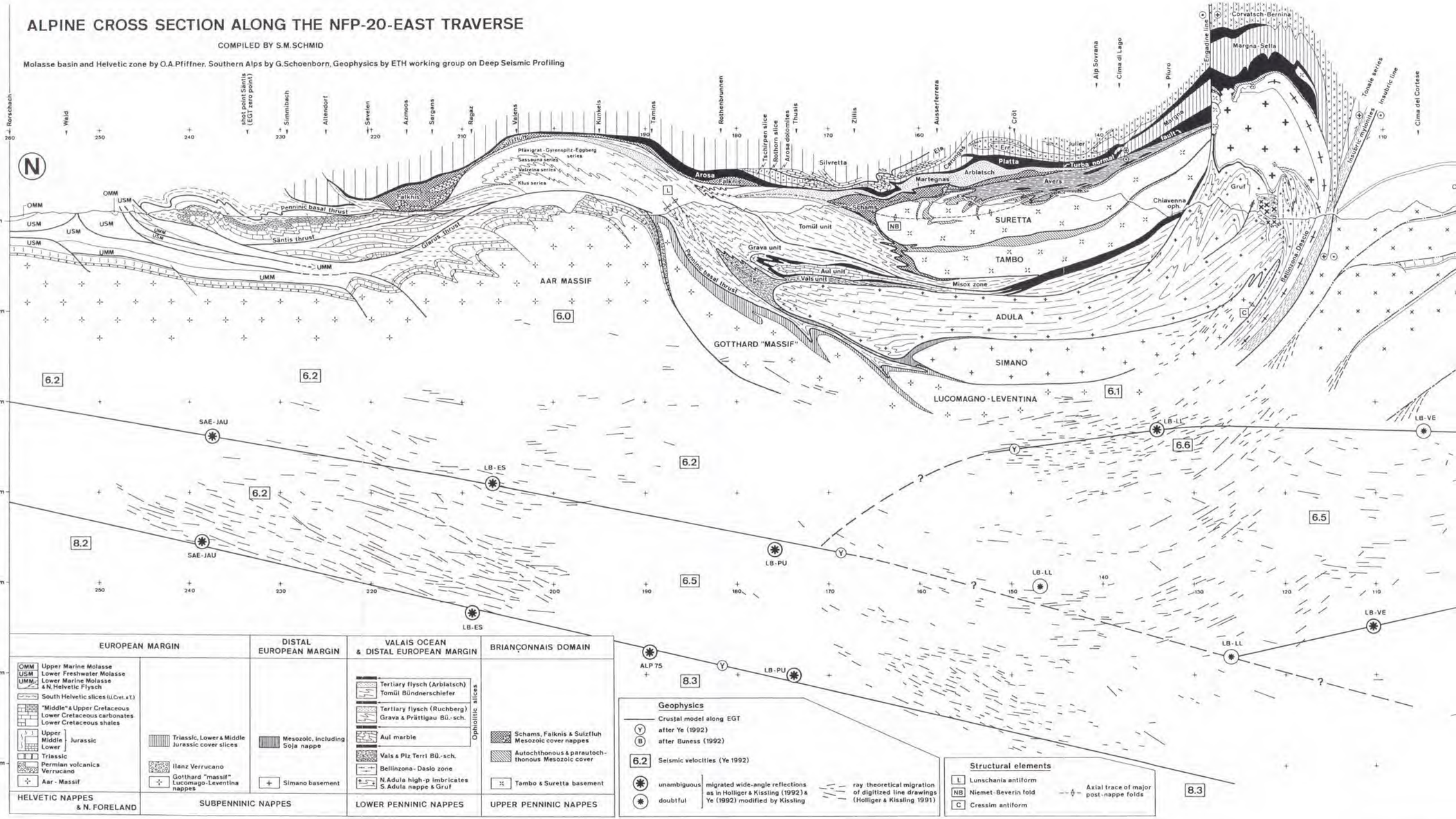

Enclosure 1

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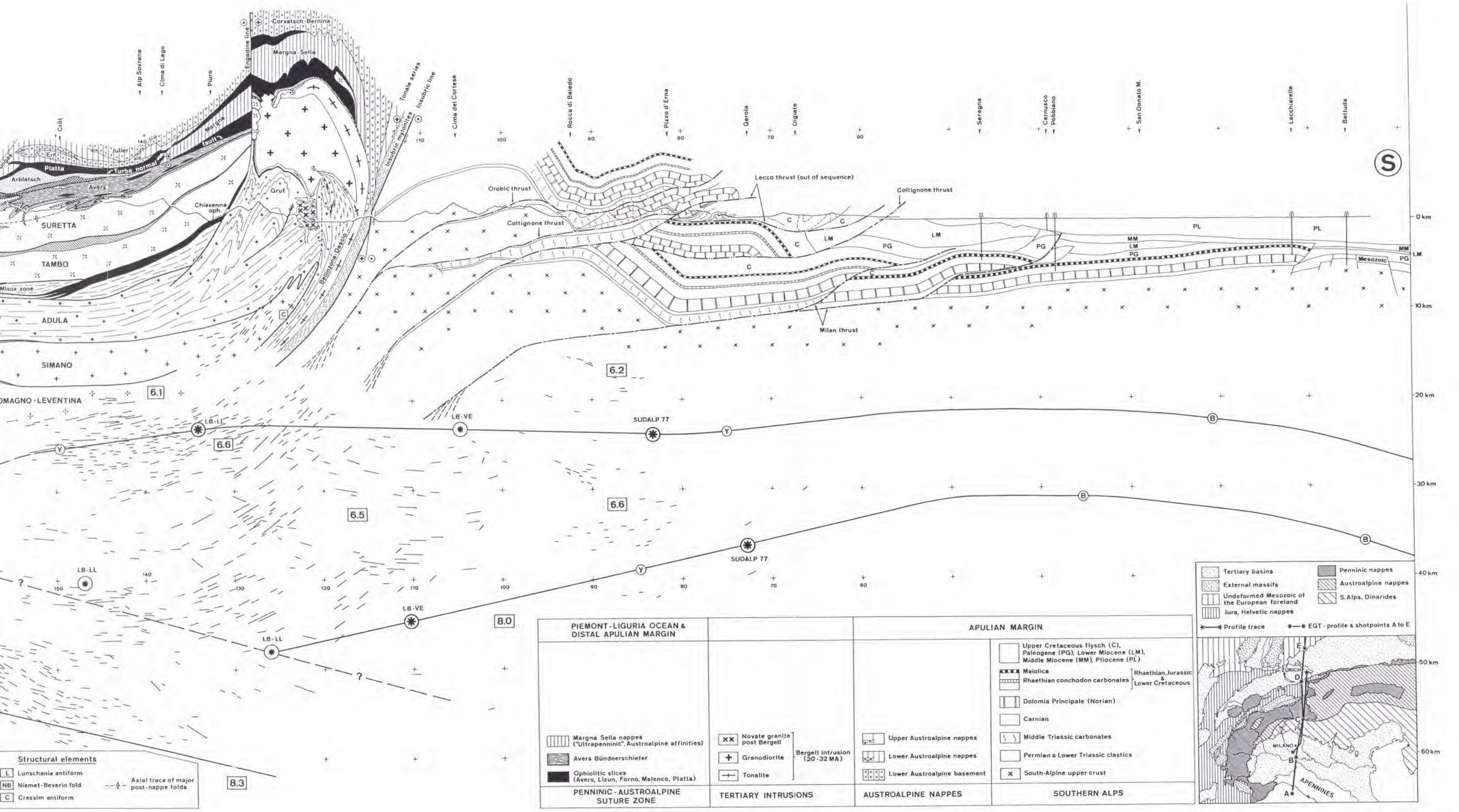
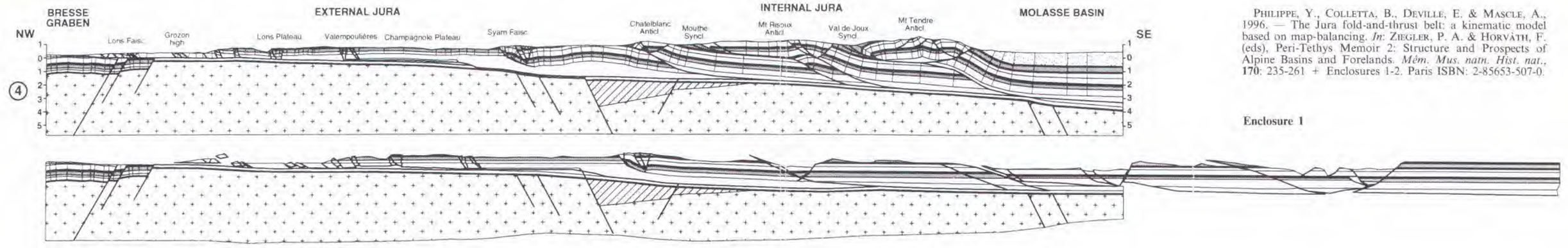
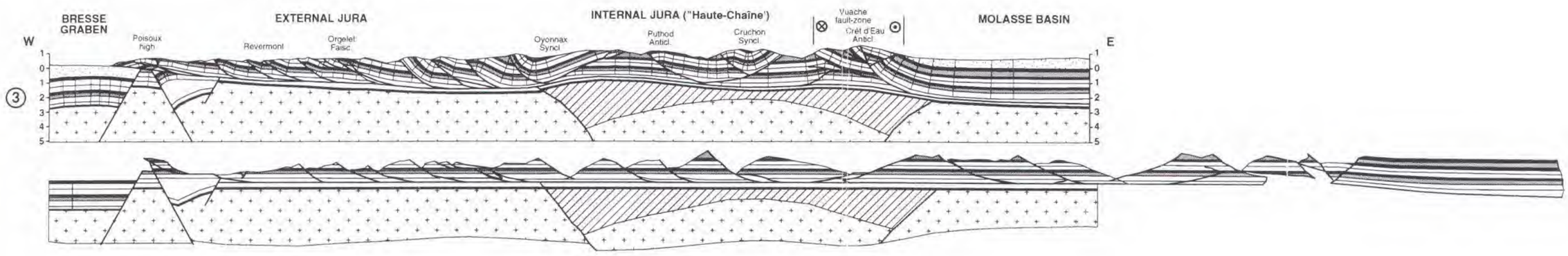


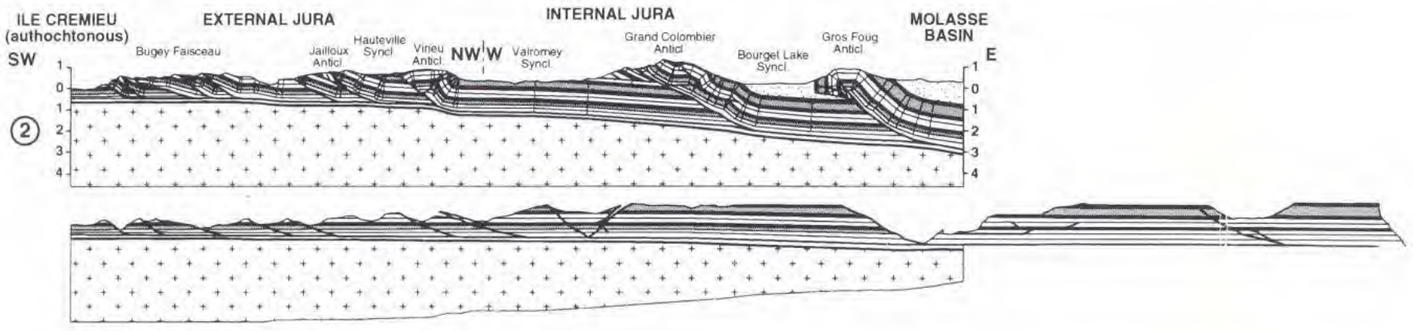
Source : MNHN, Paris

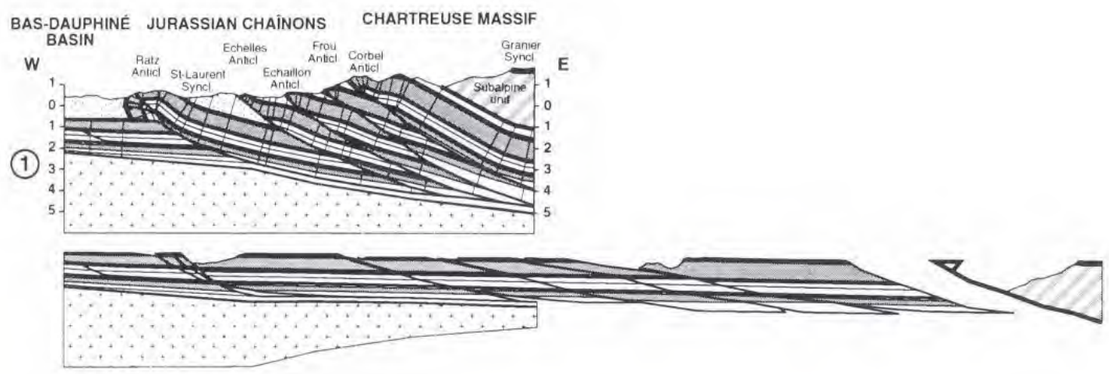
PHILIPPE, Y., COLLETTA, B., DEVILLE, E. & MASCLE, A., 1996. — The Jura fold-and-thrust belt: a kinematic model based on map-balancing. *In*: ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 235-261 + Enclosures 1-2. Paris ISBN: 2-85653-507-0.

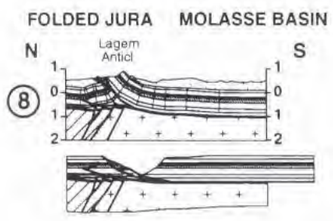
Enclosure 1

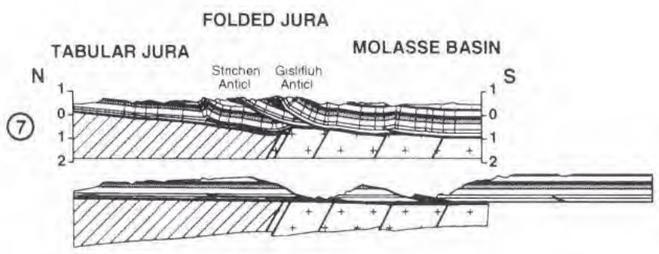


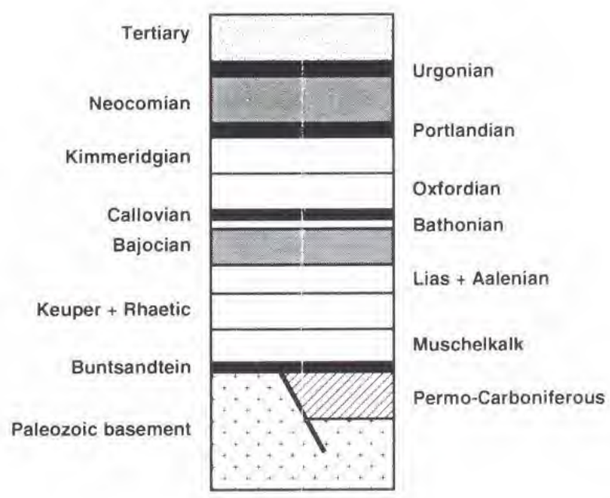


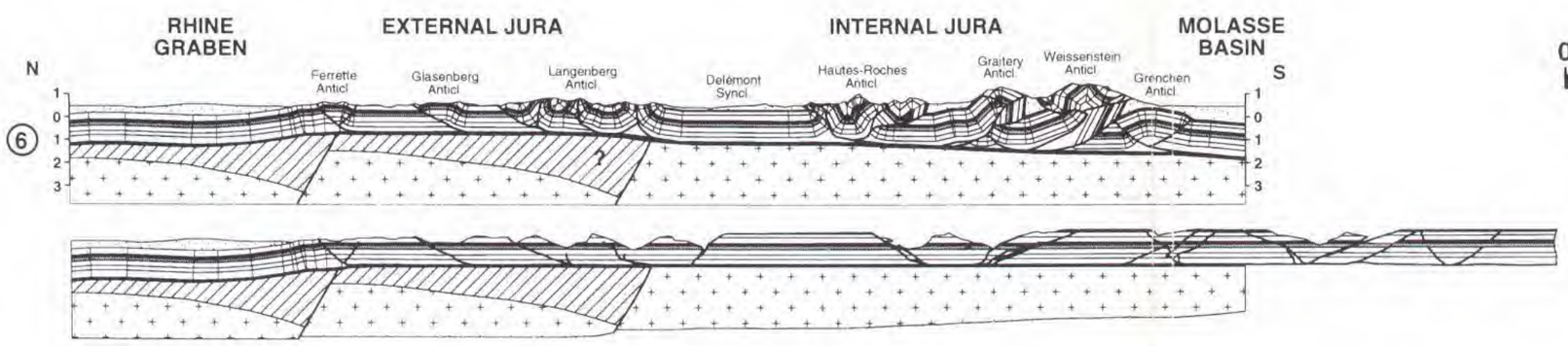


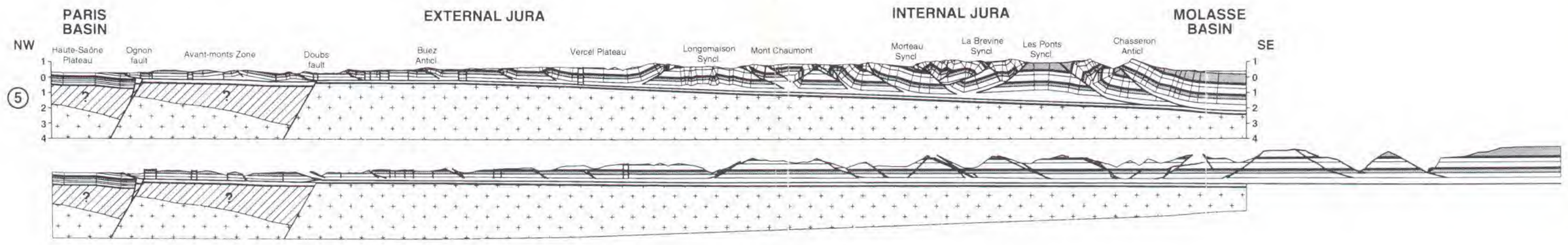


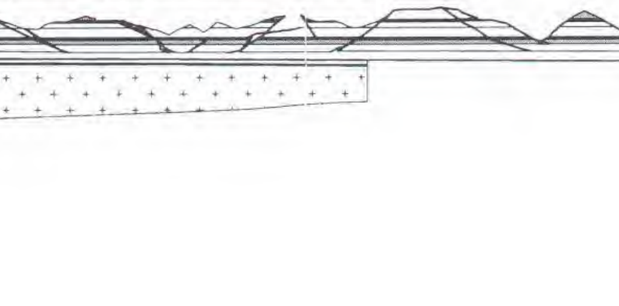












PHILIPPE, Y., COLLETTA, B., DEVILLE, E. & MASCLE, A., 1996. — The Jura fold-and-thrust belt: a kinematic model based on map-balancing. *In*: ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 235-261 + Enclosures 1-2. Paris ISBN: 2-85653-507-0.

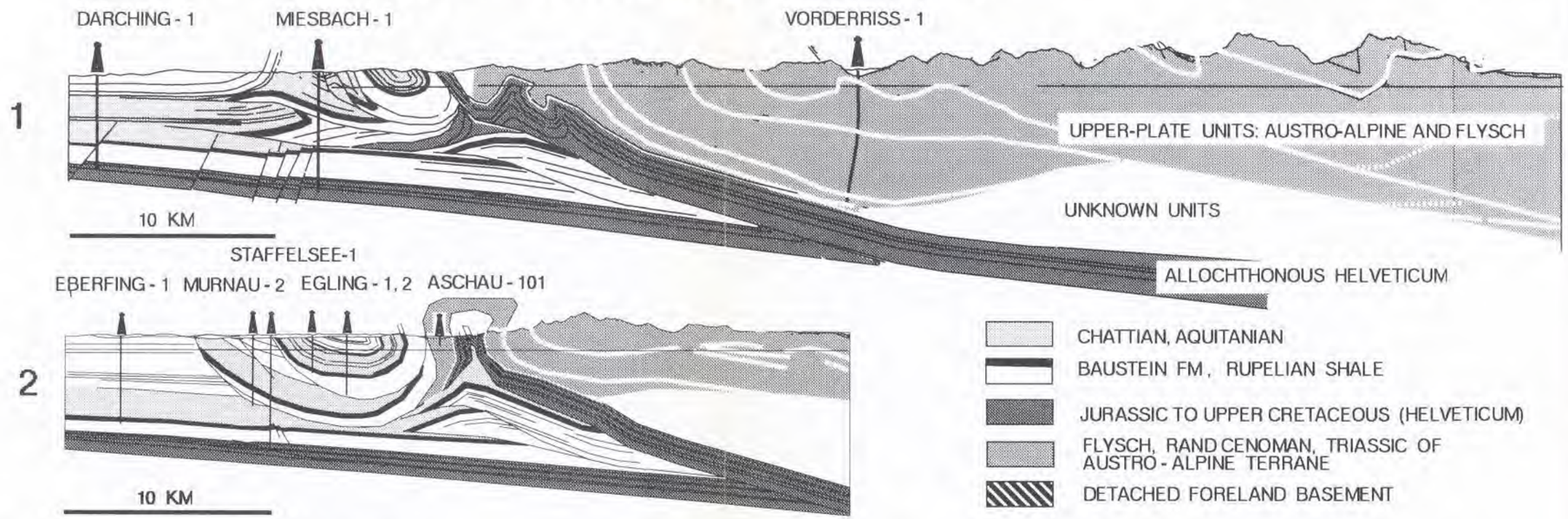
Enclosure 2

BIBL. DU MUSEUM PARIS

Source : MNHN, Paris

REGIONAL STRUCTURE CROSS SECTIONS 1, 2, 3, 4

ROEDER & BACHMANN, ENCLOSURE 1



ROEDER, D. & BACHMANN, G., 1996. — Evolution, structure and petroleum geology of the German Molasse Basin. *In*: ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 263-284 + Enclosures 1-4. Paris ISBN: 2-85653-507-0.

Enclosure 1

BIBL. DU MUSEUM PARIS

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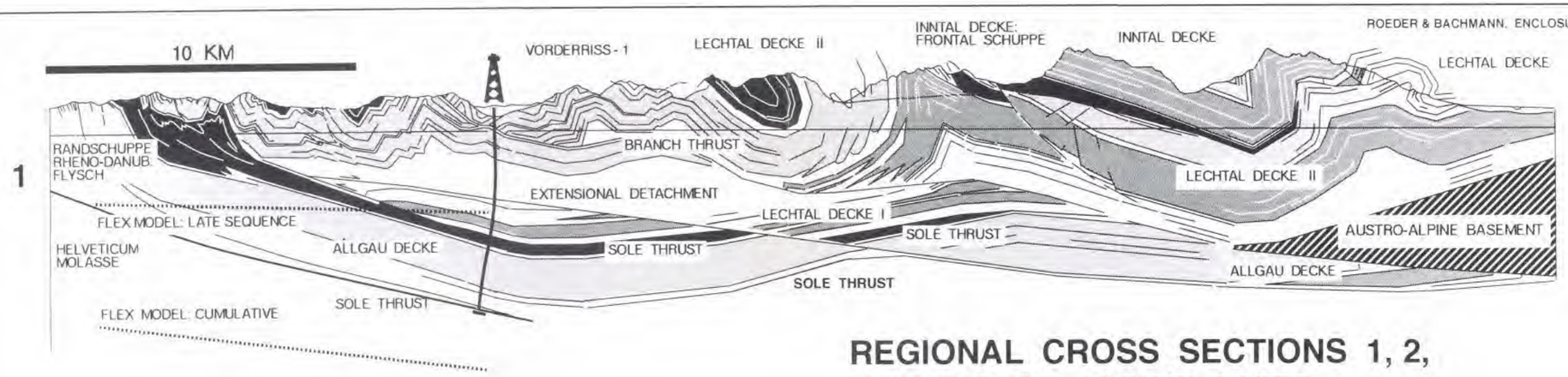
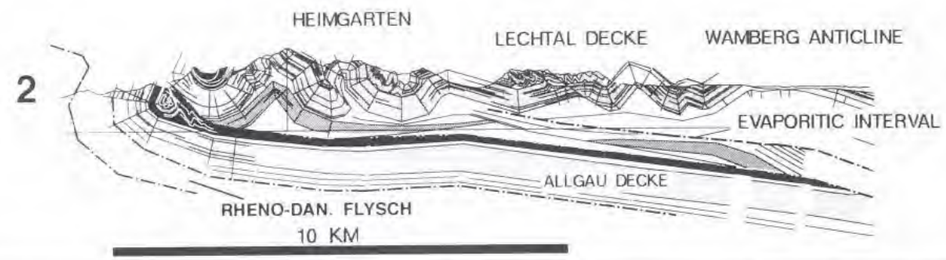




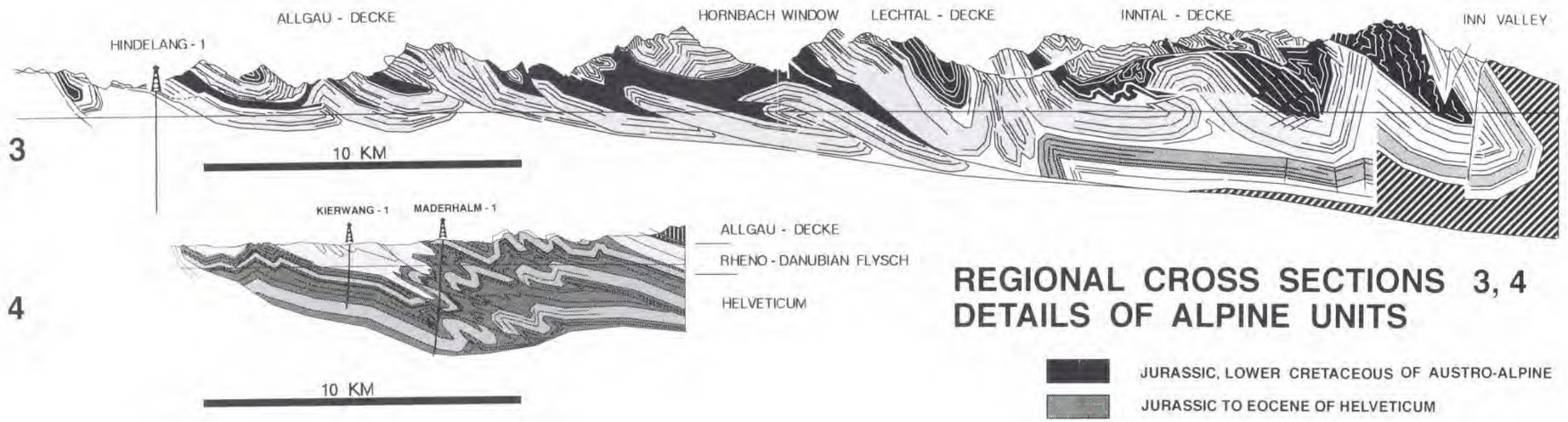
REGIONAL CROSS SECTIONS 1, 2, DETAILS OF ALPINE UNITS

- JURASSIC, LOWER CRETACEOUS OF AUSTRO-ALPINE
- JURASSIC TO EOCENE OF HELVETICUM
- NORIAN DOLOMIA PRINCIPALE (LATE TRIASSIC)
- WETTERSTEIN KALK, PARTNACH KALK (MID-TRIASSIC)
- PRE-TRIASSIC CRYSTALLINE

ROEDER, D. & BACHMANN, G., 1996. — Evolution, structure and petroleum geology of the German Molasse Basin. *In*: ZIEGLER, P. A. & HORVÀTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 263-284 + Enclosures 1-4. Paris ISBN: 2-85653-507-0.

Enclosure 2

Source : MNHN, Paris



REGIONAL CROSS SECTIONS 3, 4
DETAILS OF ALPINE UNITS

- JURASSIC, LOWER CRETACEOUS OF AUSTRO-ALPINE
- JURASSIC TO EOCENE OF HELVETICUM
- NORIAN DOLOMIA PRINCIPALE (LATE TRIASSIC)
- WETTERSTEIN KALK, PARTNACH KALK (MID-TRIASSIC)
- PRE-TRIASSIC CRYSTALLINE

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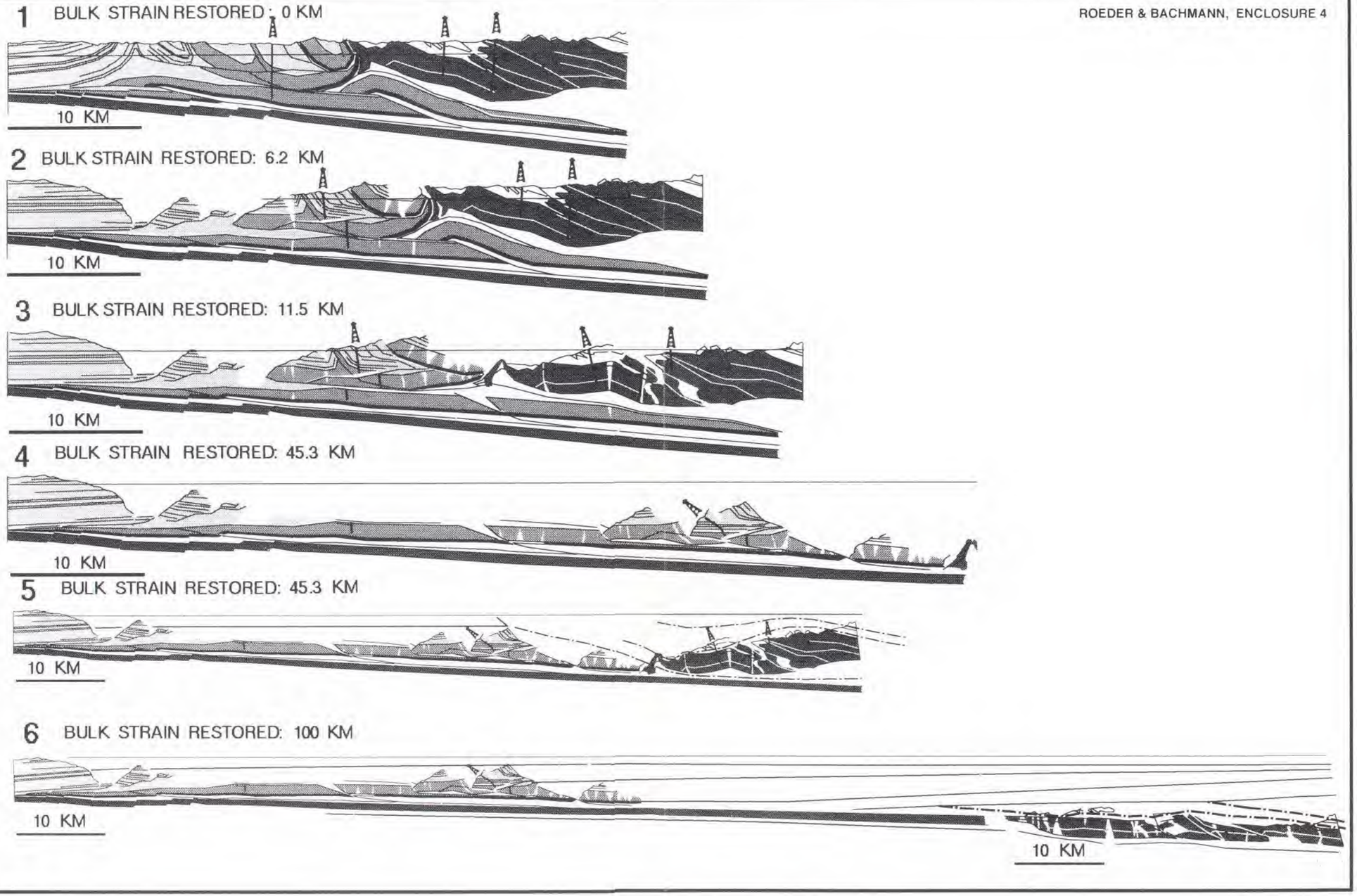

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Enclosure 4

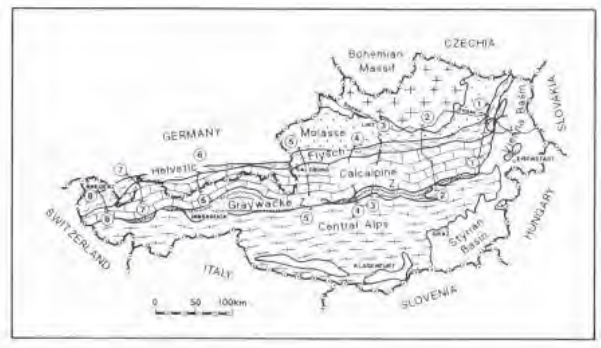
Source : MNHN, Paris

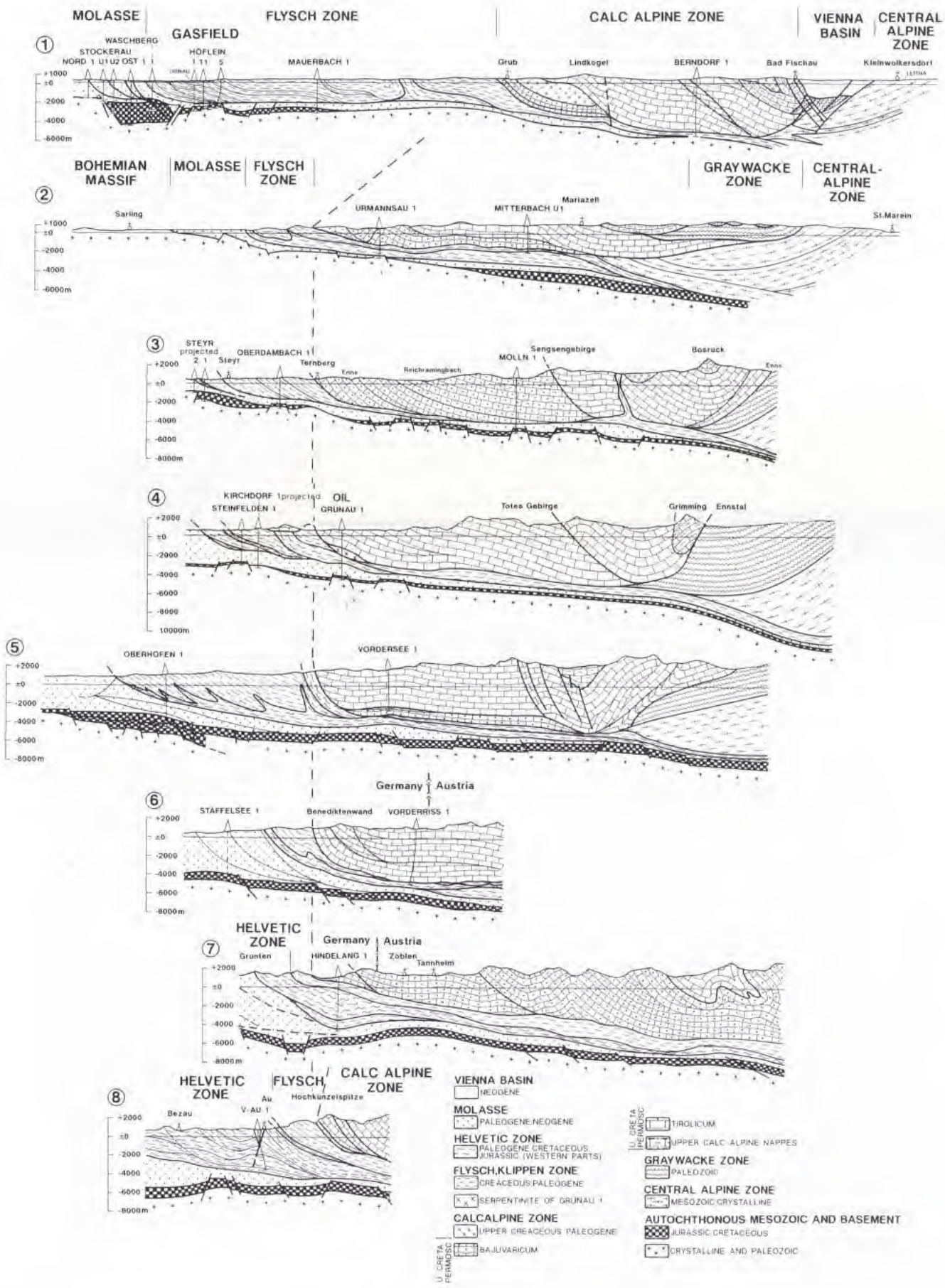
REGIONAL CROSS-SECTIONS THROUGH FLYSCH-KALKALPEN

SOURCE: G. BUCHHOLZ, E. COLINS, W. GRÜN, W. HAMILTON, P. NIEDERBACHER, R. PAVUZA, G. WACHTEL, L. WAGNER and G. WESSELY (Austria)

G. H. BACHMANN, K. HUBER, K. KOCH, M. MÜLLER, F. NIEBERDING, K. WEGGEN (Germany)

Completed: G. WESSELY





ZIMMER, W. & WESSELY, G., 1996. — Hydrocarbon exploration in the Austrian Alps. *In*: ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 285-304 + Enclosure 1. Paris ISBN: 2-85653-507-0.

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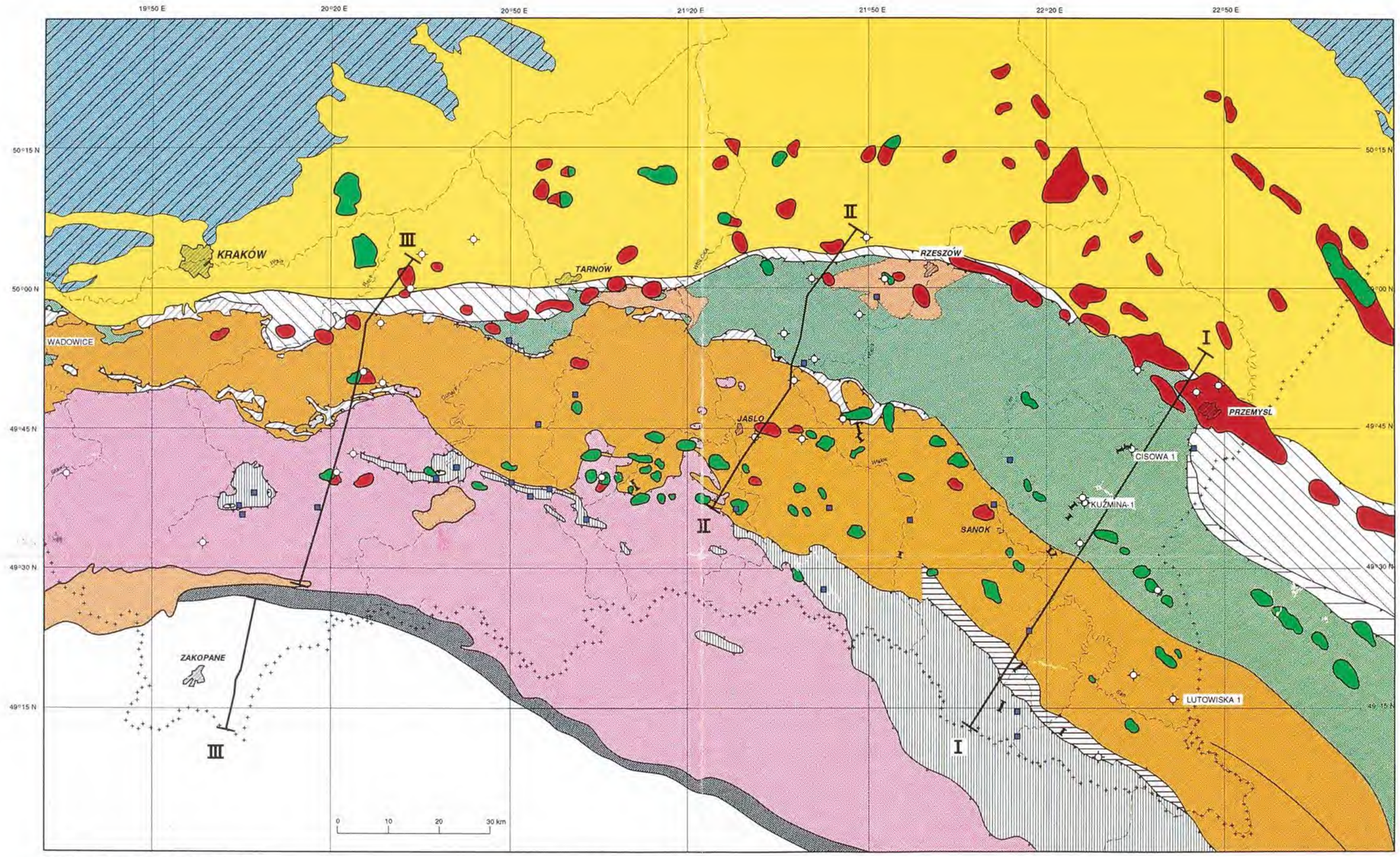

MAJOR STRUCTURAL UNITS

AUTOCHTHON

- Neogene
- Mesozoïc

ALLOCHTHON (PKB)

- Pieniny Klippen Belt

ALLOCHTHON (Outer Carpathians)

- Unconformable Miocene
- Stebnik and coeval units
- Borislav - Pokut unit
- Skole unit
- Sub-Silesian unit
- Silesian unit
- Fore - Dukla unit
- Dukla unit
- Magura unit

- Oil field
- Gas field

Location of samples studied in geochemistry

- Wells
- Outcrops

BESSEREAU, G., ROURE, F., KONTARBA, A., KUSMIEREK, J. & STRZETELSKI, W., 1996. — Structure and hydrocarbon habitat of the Polish Carpathians. *In:* ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 343-373 + Enclosures 1-3. Paris ISBN: 2-85653-507-0.

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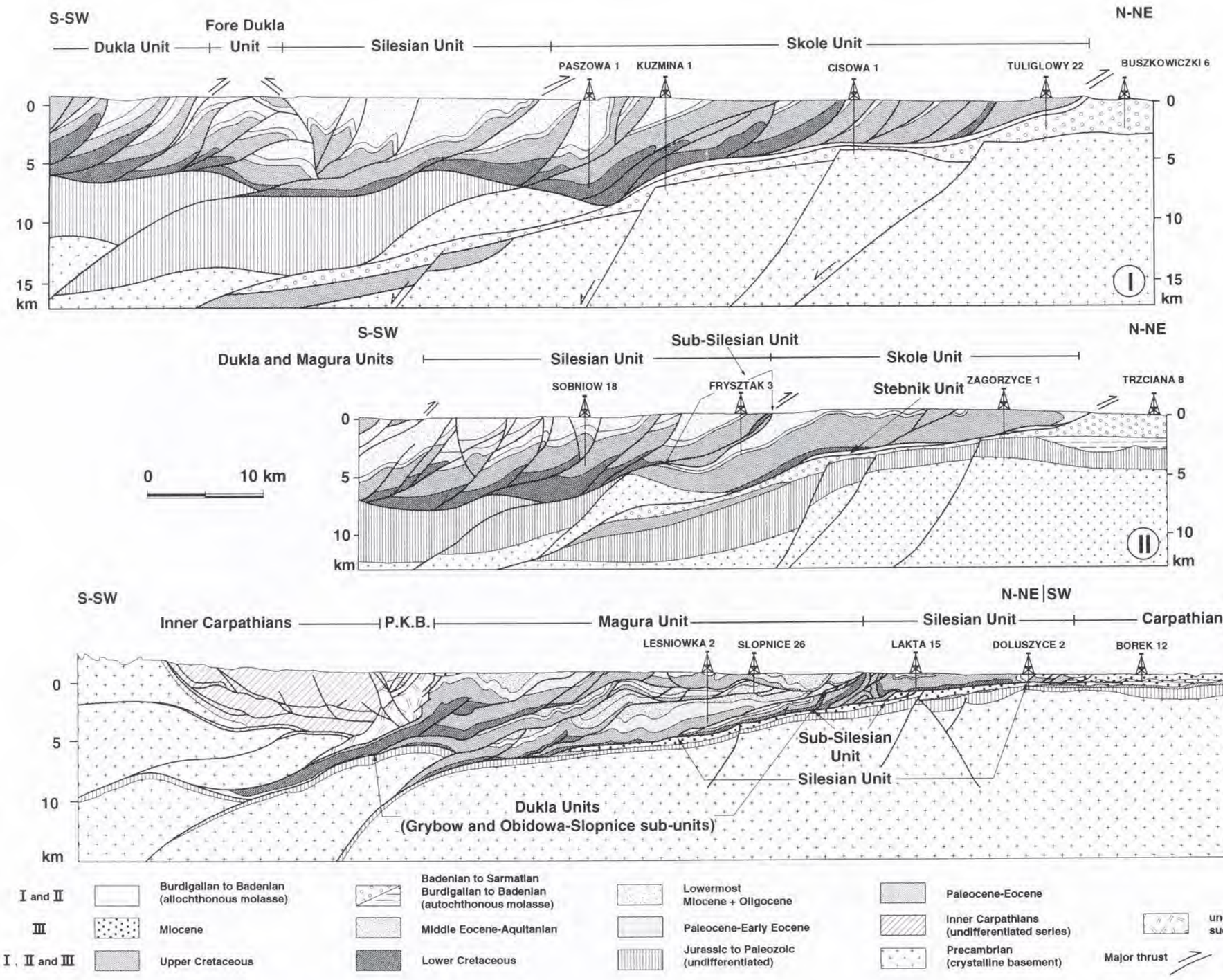

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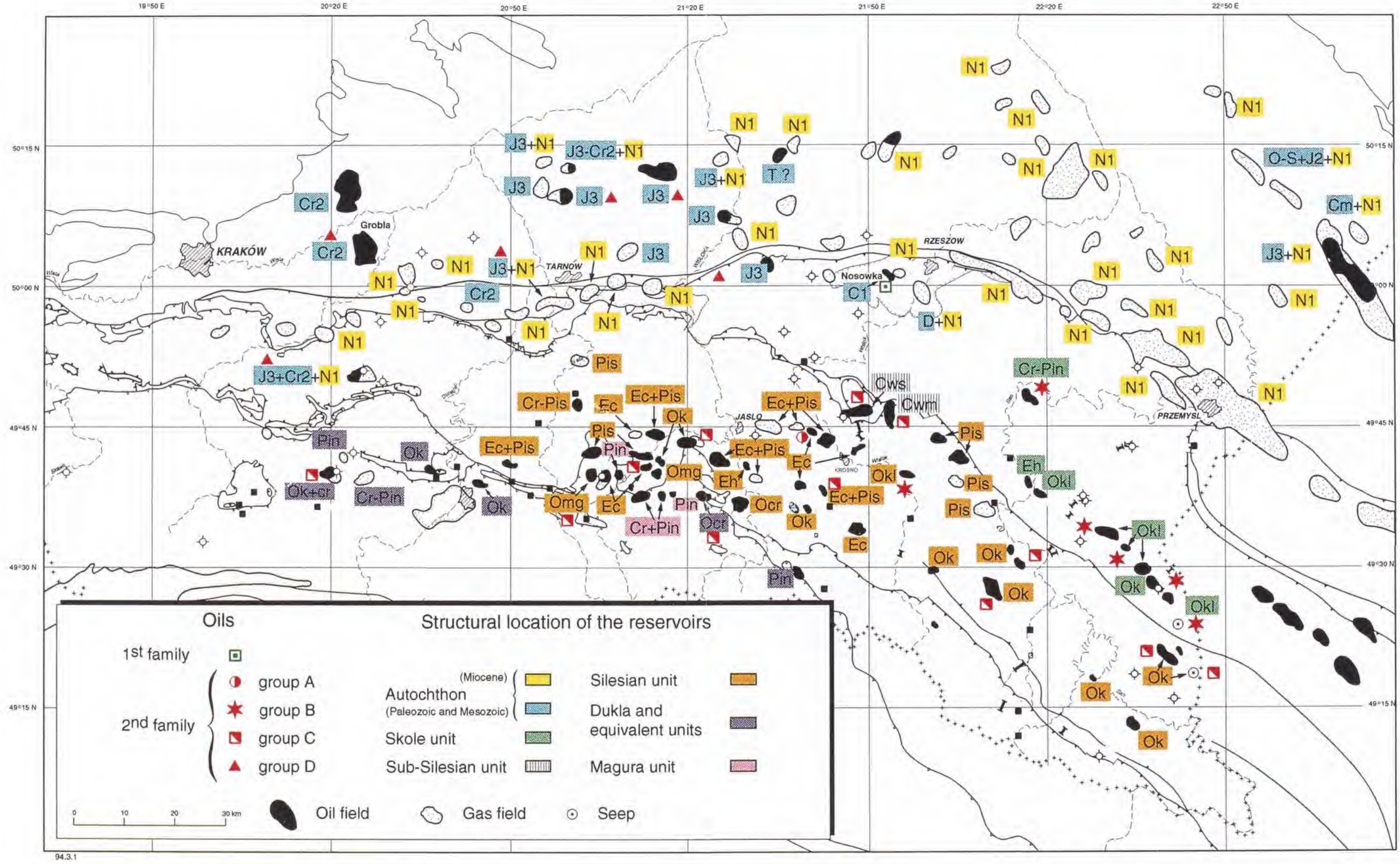

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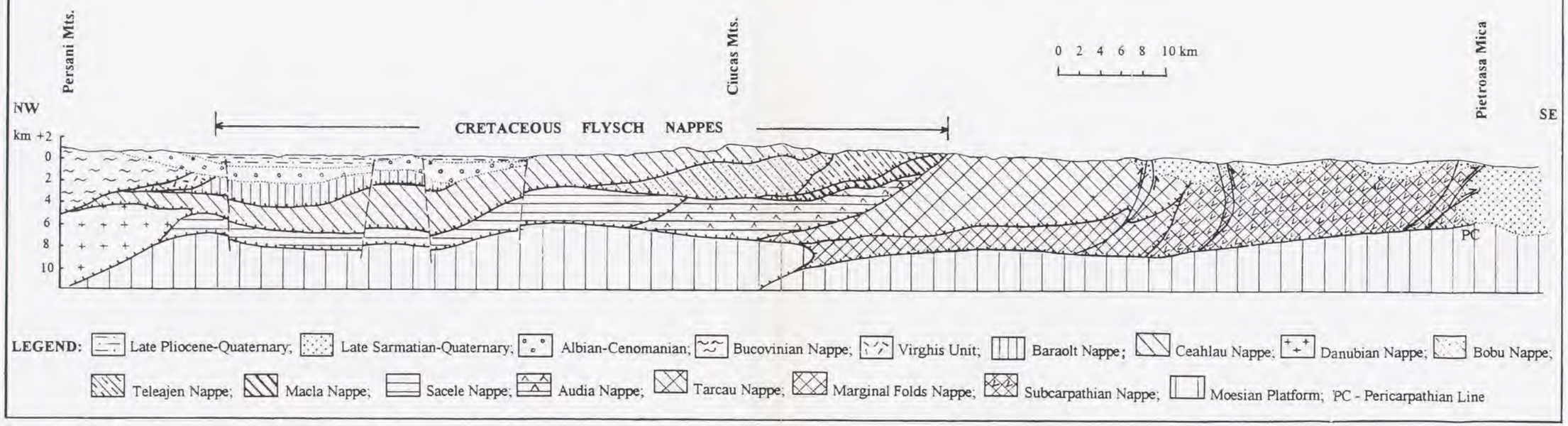
PERSANI - CIUCAS - PIETROASA SIMPLIFIED GEOLOGICAL CROSS-SECTION



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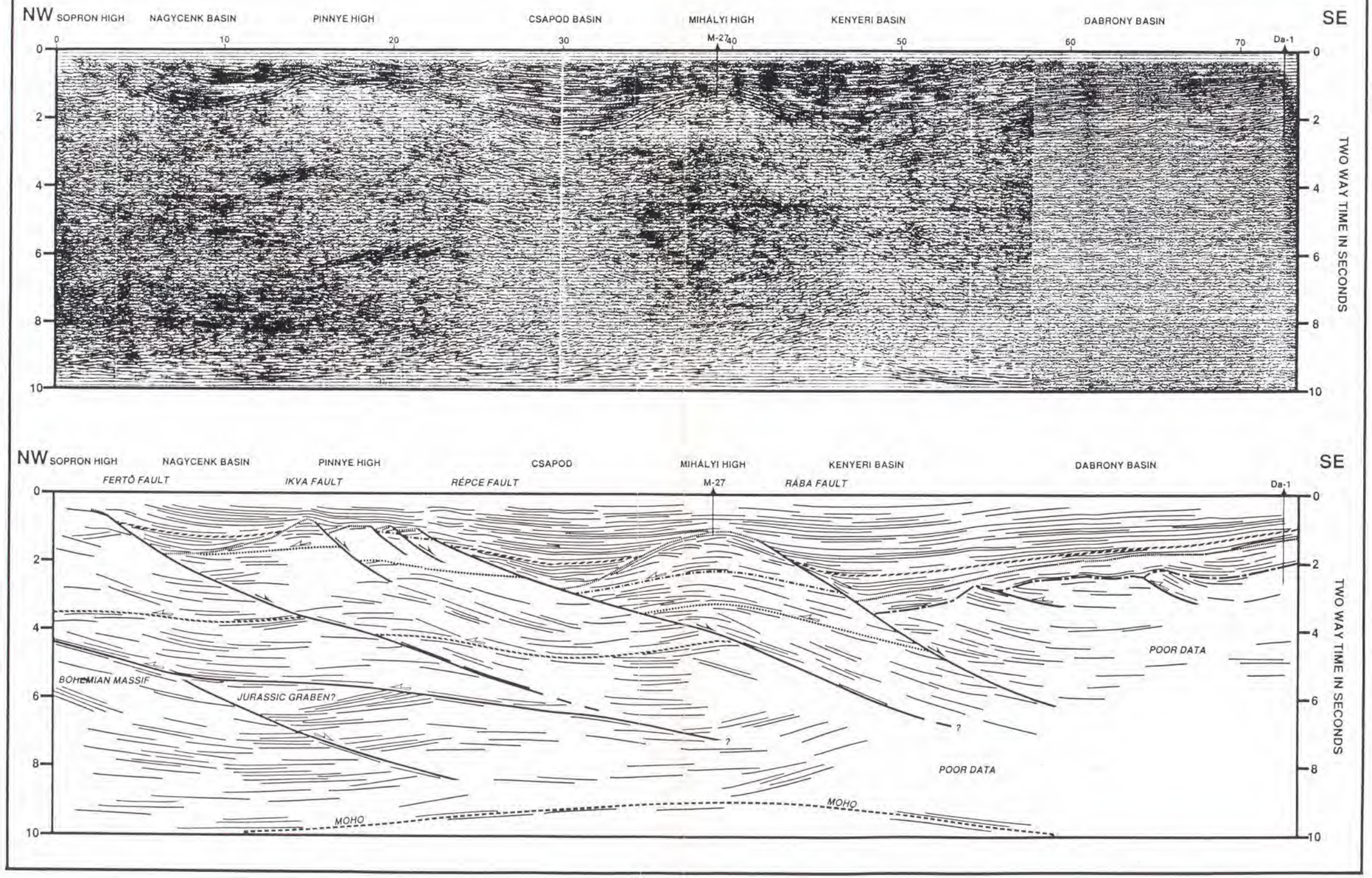

TARI, G., 1996. — Neoalpine tectonics of the Danube Basin (NW Pannonian Basin, Hungary). *In*: ZIEGLER, P. A. & HORVÁTH, F. (eds), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. *Mém. Mus. natn. Hist. nat.*, **170**: 439-454 + Enclosures 1-3. Paris ISBN: 2-85653-507-0.

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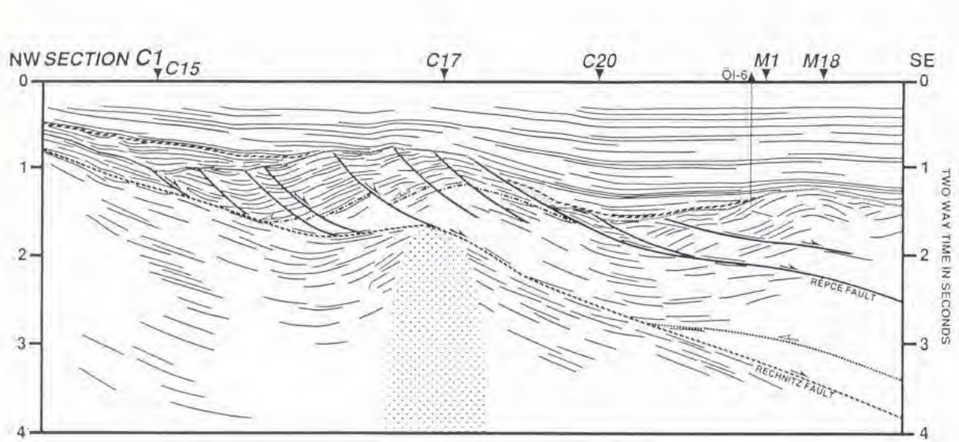

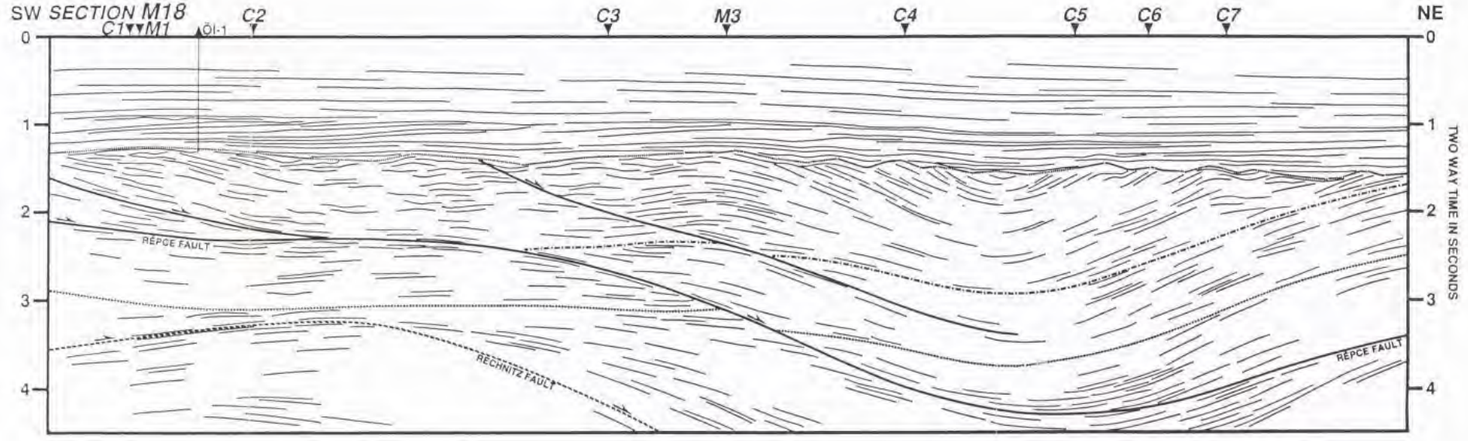

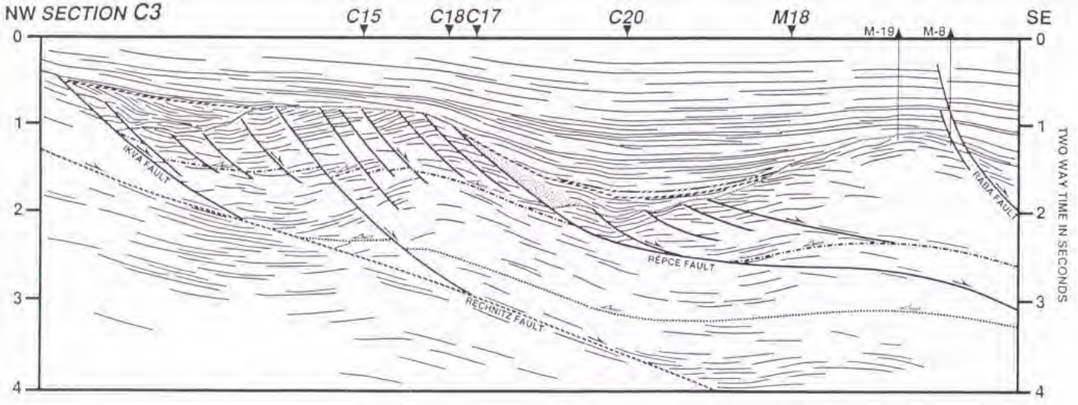

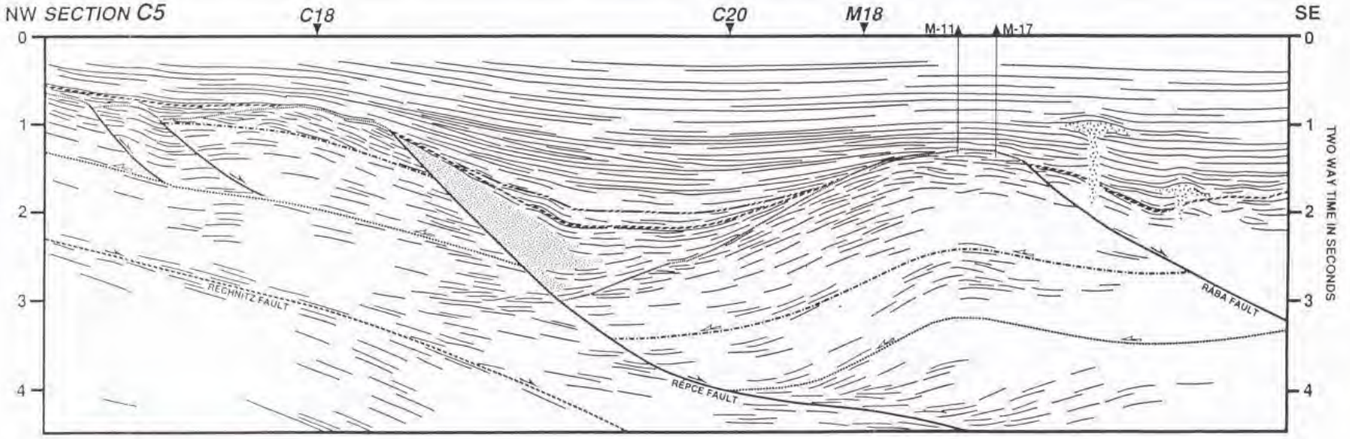

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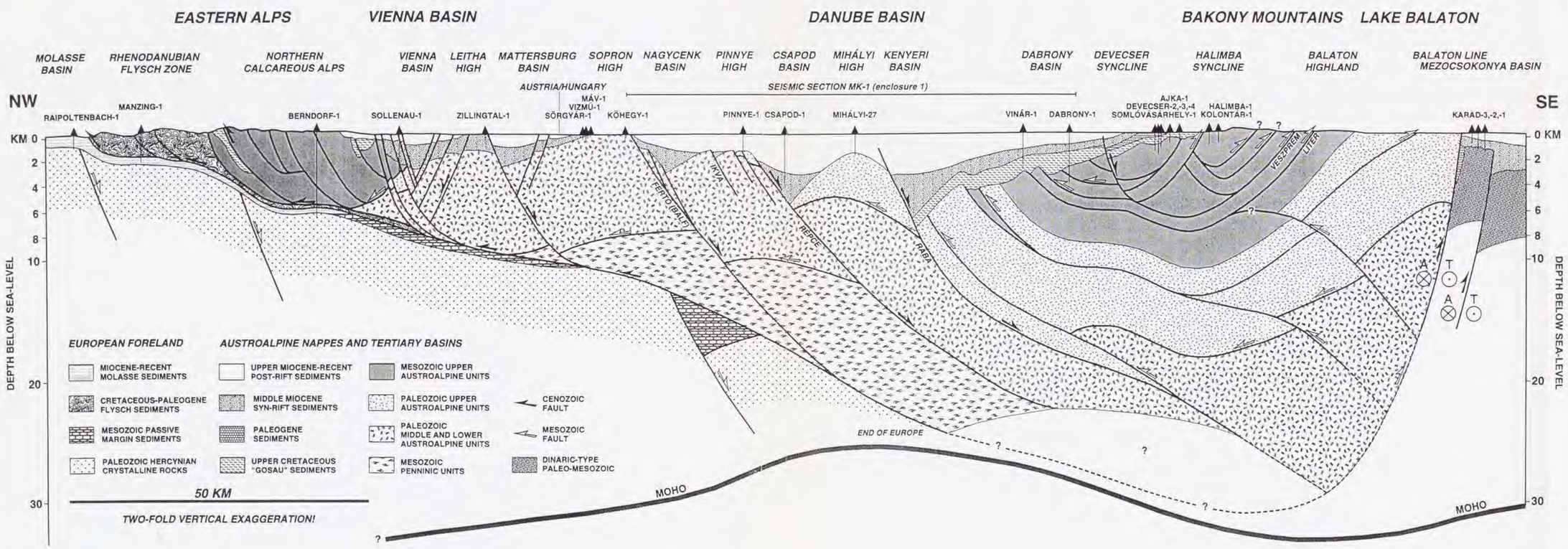

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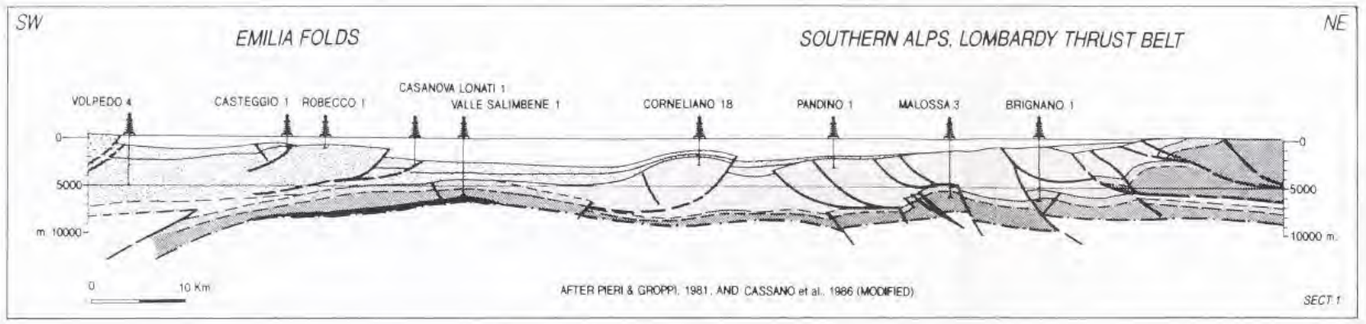
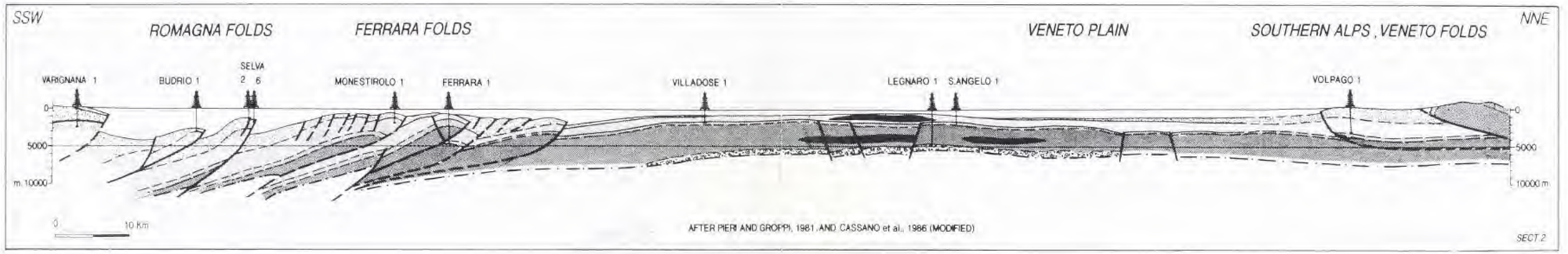
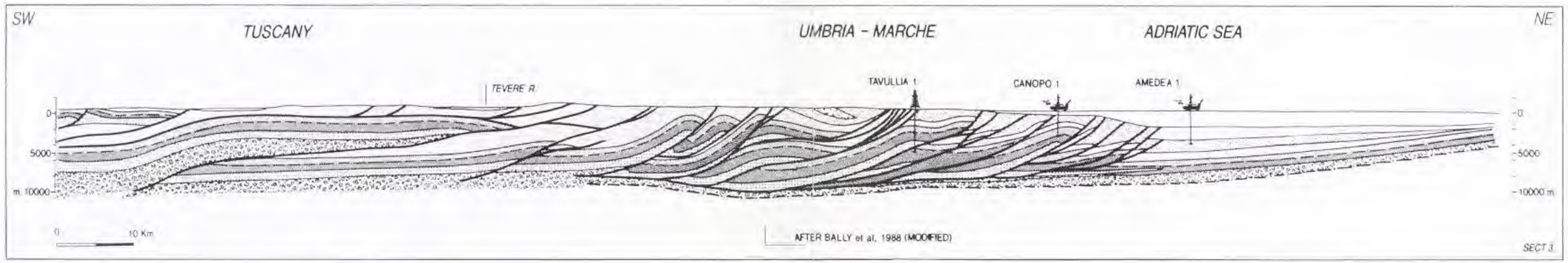


- M-L PLIOCENE-QUATERNARY
- MESSINIAN-EARLY PLIOCENE
- PALEOGENE-MIOCENE
- TRIASSIC-JURASSIC-CRETACEOUS (PELAGIC FACIES)
- TRIASSIC-JURASSIC-CRETACEOUS (PLATFORM FACIES)
- LATE TRIASSIC EVAPORITES AND DOLOMITES
- PERMIAN-EARLY TRIASSIC SILICICLASTICS
- VOLCANICS
- LIGURIDES NAPPE
- TOP OF MAGNETIC BASEMENT

(TRACES ON Fig. 5)





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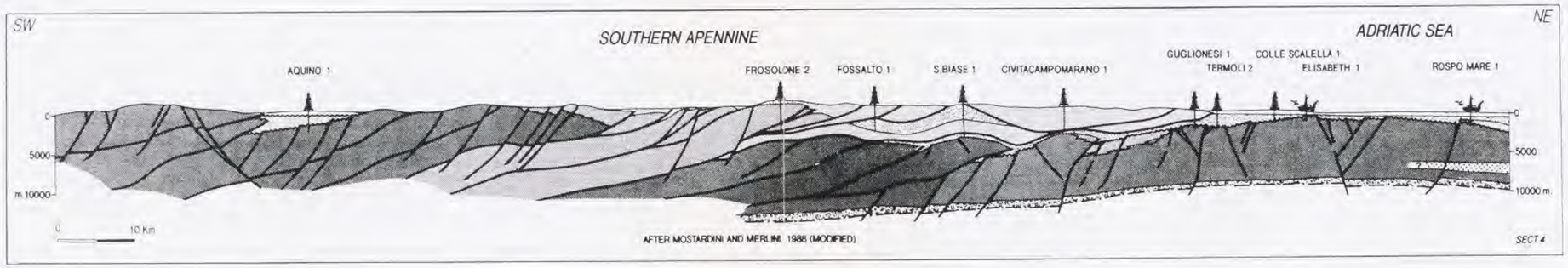

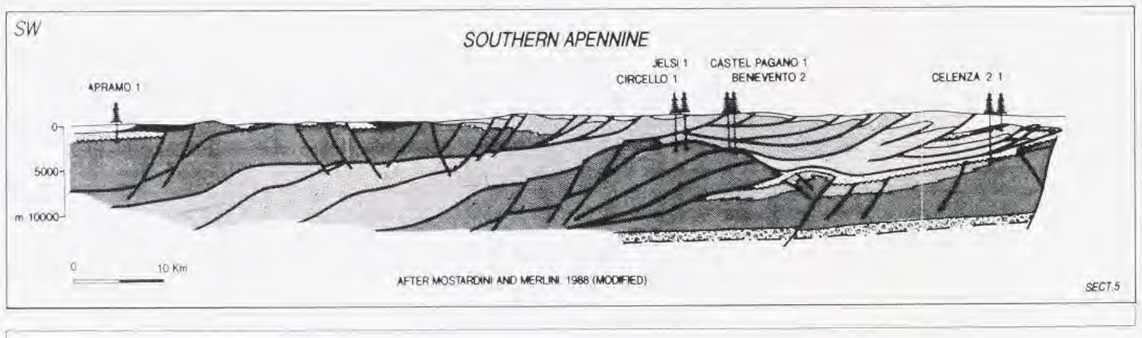

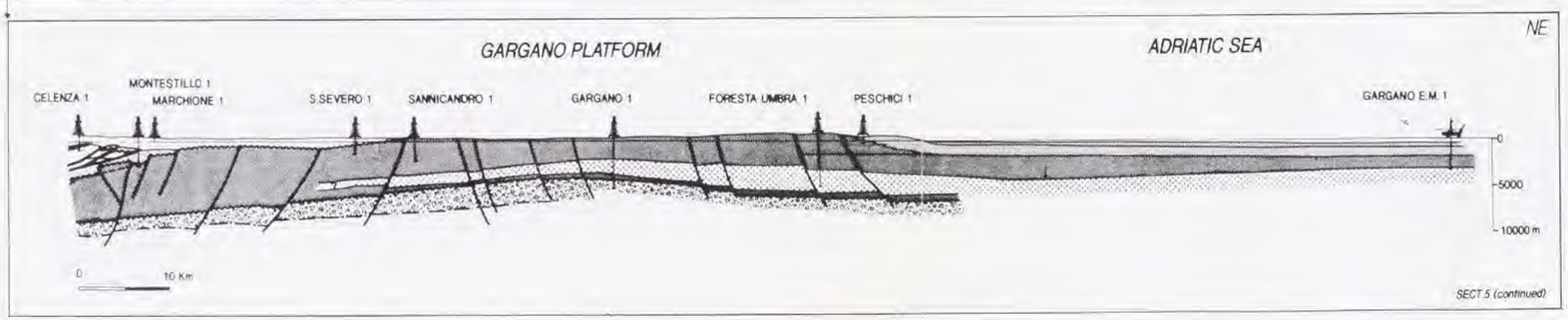

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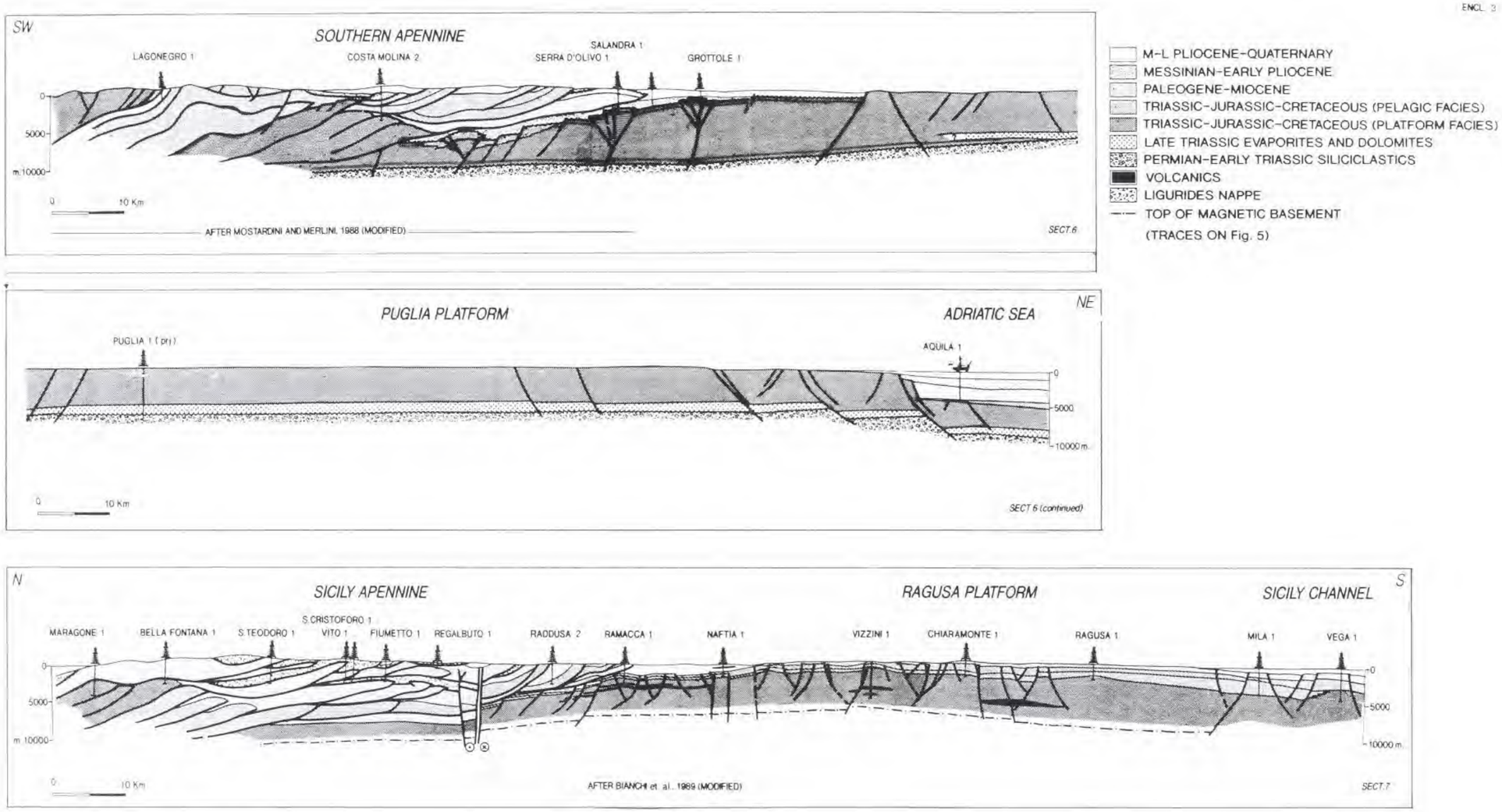

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Enclosure 3

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Peri-Tethys Memoir 2 addresses the stratigraphic and structural evolution of the Alpine-Mediterranean orogen and its hydrocarbon systems. Geographic coverage reaches from Morocco via the Pyrenees, Alps, Carpathians, Apennines and Albanides to the Crimea and southern Turkey. This memoir is the product of close cooperation between academic and industrial Earth scientists. All papers are based on recent compilations, integrating surface and sub-surface geological and geophysical data acquired during hydrocarbon exploration and/or scientific programs. They are aimed at unravelling the architecture and origin of specific fold-and-thrust belts or basins. Much of the data presented have not previously been published or were inaccessible to Western readers. The memoir consists of a 552 page volume containing 24 richly illustrated papers with many black and white and colour figures, and a box, which contains 31 loose leaf foldouts, 20 of them in colour, presenting maps, cross-sections and seismic profiles.

Peter A. ZIEGLER (Geological-Paleontological Institute, University of Basel, Switzerland, retired petroleum geologist) and Frank HORVÀTH (Geophysical Institute, Loránd Eötvös University, Budapest, Hungary) convened the American Association of Petroleum Geologists Symposium held in The Hague out of which this memoir developed.

PERI-TETHYS PROGRAMME

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